IMPROVED COST ESTIMATION FOR SOLID WASTE MANAGEMENT

IN INDUSTRIALISING REGIONS

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

The need for improving cost estimation for *solid waste management* (**SWM**) is particularly strong in emerging (industrialising) economies where problems of solid waste are severe, expectations for improvements are high, but finances are constrained.

Using literature-based evaluation, traditional methods used to estimate costs of SWM in industrialising regions are classified into two categories- the unit cost method and benchmarking techniques. These current approaches are unable to satisfy two important SWM objectives in industrialising regions- 1. provide an understanding of variables affecting costs of SWM in developing countries, which in turn helps in developing a sound financing strategy, and 2. ensure that scarce financial resources are used to best effect while planning for increasing populations, and raising service levels in developing countries The development of cost models using the cost function approach, which are sometimes used as a cost estimation technique for developed countries' waste management case studies, is deemed as an improvement over current cost estimation approaches for SWM used in industrialising regions.

The usefulness, applications and limitations of the cost function approach for developing countries is shown in four ways. First, the application of the cost function

methodology to a developing country dataset is shown using data from approximately 300 Indian municipalities. Second, future developmental scenario analyses is conducted at the city level to estimate marginal costs to improve solid waste management (SWM) to handle increasing populations and to raise the level of service. Third, the basic intents for conducting cost function analyses are categorised based on the rich experiences from another public service with many similar characteristics, namely the healthcare sector, and translated for easy understanding for future solid waste engineers. Finally, the potential implications of the health care analyses on the developing city case study demonstrates the way forward in terms of the most important data that needs to be collected and future cost analyses that needs to be conducted.

The results from this work indicate a strong need for careful selection and management of data, and awareness of the challenges that developing country datasets pose. The thesis is designed to encourage planners in developing countries to ditch heuristic thinking when planning improvements to SWM, and instead adopt modern rational methods to make cost-wise decisions. Specifically, this thesis provides solid waste management analysts the necessary tools to gather, analyse and interpret cost information in a way that facilitates planning of restricted finances in industrialising regions.

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Dedication

I dedicate this thesis to my dad *S. Parthan*- the strongest, most enthusiastic individual, and tireless solid waste management crusader I have ever known; you will forever be my role model.

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Name: Mark Wilke Signature: Date: 9 Aug. 12

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GLOSSARY OF ABBREVIATIONS

CBO	Community based organization
CoC	Corporation of Chennai
CPC	Cost per capita
CPT	Cost per tonne
CWG	Collaborative Working Group
D-T-D	Door to door
ERM	Environmental Resources Management
EU	European Union
GTZ	German Technical Cooperation
HMV	Heavy motor vehicles
IR	Industrialising regions
ISWM	Integrated and sustainable waste management
LAWRRD	Local Authority Waste Recycling Recovery and Disposal
LMV	Light motor vehicles
MoEF	Ministry of Environment and Forests
MRF	Material Recovery Facility
MSW	Municipal solid waste
NGO	Non-governmental organization

NIUA	National Institute of Urban Affairs
PFD	Process flow diagram
RPA/SAM	Recycling Potential Assessment and System Analysis Model
RWO	Resident welfare organization
SWM	Solid waste management
UCM	Unit Cost Method
UN- Habitat	United Nations- Habitat
USD	United States Dollar
USEPA	United States Environment Protection Act
WHO	World Health Organisation
WPA	Waste collected per unit area

CHAPTER 1: INTRODUCTION

1.1 Foreword

This thesis contributes to the topic of cost estimation for municipal solid waste management. The focus is on developing countries, specifically on transitional economies where, in spite of growing national wealth, the mounting amounts of uncollected waste are increasingly becoming an eyesore and relatively expensive to manage. The broad objectives of the thesis are to examine what approaches for cost estimation have previously been used, how the best methods among those approaches can potentially be applied to a developing country and city dataset, what future cost estimation analyses are most useful and finally what kinds of data are needed to perform such analyses. The outcome of this thesis is not to develop a guidebook or framework for estimating costs for waste management. The most desirable outcome would be to show how to collect and analyse cost information in a way that facilitates planning for improving coverage and service levels for a developing country. If this thesis can contribute to that outcome, the job will have been well done.

The aim of this chapter is to describe the basics of solid waste management, such as definitions and principles, developing country practices, and challenges. The discussion then shifts to the main focus of the thesis (i.e, cost estimation related), where previous literature and what is lacking in this topic are discussed. The chapter concludes with the objectives being specified and an outline of the remaining thesis structure.

1.2 Describing municipal solid waste management

1.2.1 Definitions

The following definitions are compiled from a number of sources (Hanrahan et al., 2006; NIUA, 2005; Scheinberg et al., 2010b; Schübeler et al., 1996; Zhu et al., 2008; Zurbrugg, 2002)

Municipal solid waste is the non-liquid material, more commonly known as trash, garbage, rubbish or refuse, generated by households and institutions (e.g. schools, hospitals, offices etc.), found in public spaces (e.g. streets, markets, gardens), and the non-hazardous material from commercial, industrial, construction and demolition sites, that no longer has any value to the generators of that waste.

Municipal solid waste management refers to the public service of handling municipal solid waste via collection and subsequent transfer, treatment, disposal, and recycling. (Readers are asked to note that the term municipal solid waste management is frequently shortened to solid waste management (abbreviated as SWM) in the rest of this thesis, but both have the same meaning).

1.2.2 Goals and principles of SWM

Integrated and sustainable waste management (ISWM) is the 'mantra' for good practice in SWM. An ISWM framework for low and middle income countries was first developed in 1996 as a lens to view a developing city's SWM system (Wilson and Scheinberg, 2010). A further simplified version of the framework was re-established in a recent UN-Habitat publication by Scheinberg et al (2010b). The authors describe the six main objectives or drivers for a ISWM service. The first three of the following are technical drivers while the next three are essential governance features:

- To improve public health (through better waste collection coverage)
- To protect the natural environment (through better waste treatment and disposal measures)
- To better manage useful resources in the system (by reducing, reusing and recycling municipal solid waste)

- Informed decision making, implementation and monitoring (by involving stakeholders, i.e. providers, users and financers, in the process)
- Financial sustainability (by improving cost estimation and planning, and delivering cost-effective and affordable services)
- Address underlying management issues (by ensuring transparency through good accounting procedures, strict consequences for corruption, and last but not the least political commitment)

1.3 Solid waste management in developing countries

1.3.1 Material flow paths and activities

A process flow diagram (PFD) is a flowchart that maps out both solid waste activities and waste flow paths in an existing waste management system (see example of a PFD in Figure 1.1). A PFD helps in understanding the complex inter-relationships between waste management activities and stakeholders in developing countries(Wilson et al., 2012)

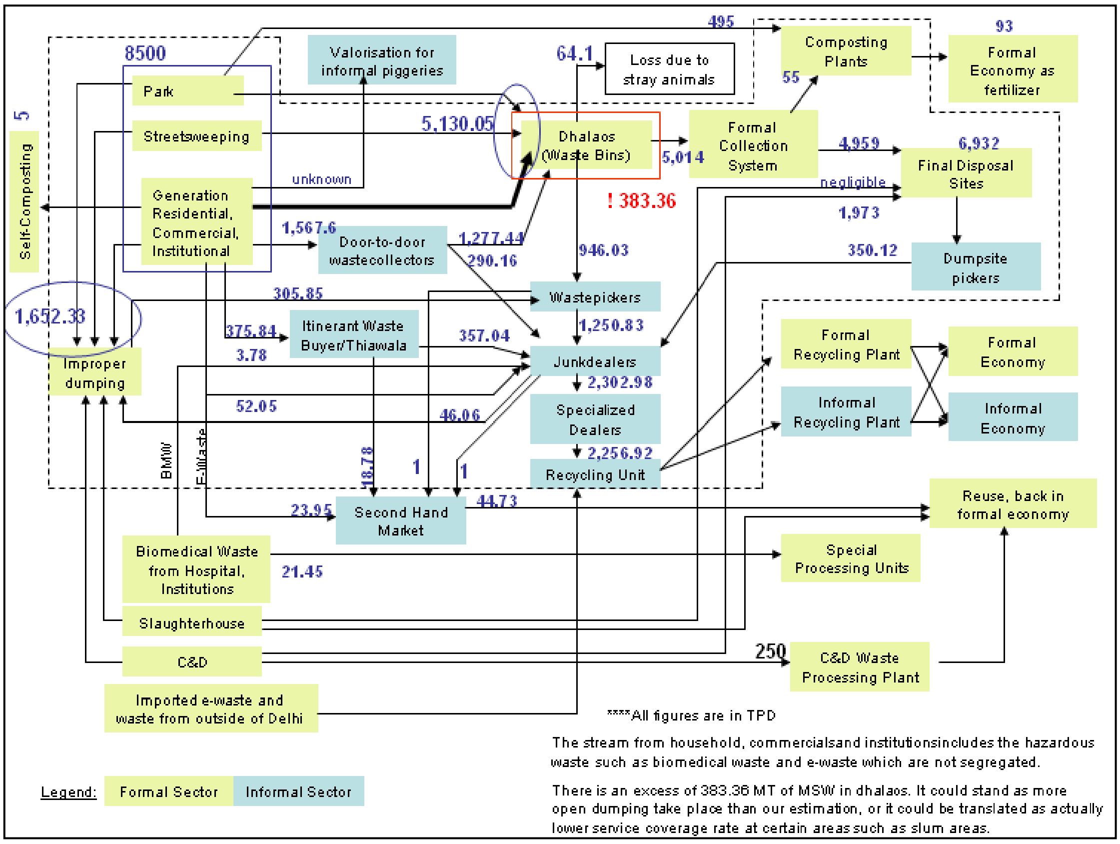

Figure 1.1: A Process Flow Diagram of SWM in Delhi, India
(Source: Scheinberg et al.(2010b))

Note how generated wastes are managed parallely between different stakeholders in Figure 1.1 (e.g., residents directly sell wastes to second hand markets, itinerant waste buyers buy it from households, and the municipality collects from community bins/dhalaos). Also note how Figure 1. 1 shows that the majority of wastes in Delhi are managed by the 'informal sector' (more about informal sector later in this section).

This could act as an indication to decision-makers that streamlining future finances towards their existing strengths, by building the capacity of the informal sector, would be a good strategy to adopt in order to ensure cost savings in Delhi's case.

The USEPA SWM handbook suggests that a flowchart that chalks out both activities and paths is the best first step towards minimizing costs and environmental effects, and maximizing recovery and conservation of energy and materials (USEPA, 1997). A PFD like Figure 1. 1 demonstrates that there are two ways of disintegrating the entire SWM system; one focusing on activities and another focusing on paths that MSW follows. Both activities and flow-paths are useful for future planning(USEPA, 1997). By looking into MSW activities, one can work out what it costs to run the system and changes can be made to improve the cost efficiency of the system. Whereas the material flow is useful in deciding whether to shift the flow of waste one way or another for better material recovery and environmental protection.

A simplified general version of the PFD for developing countries is presented in Figure 1.2.

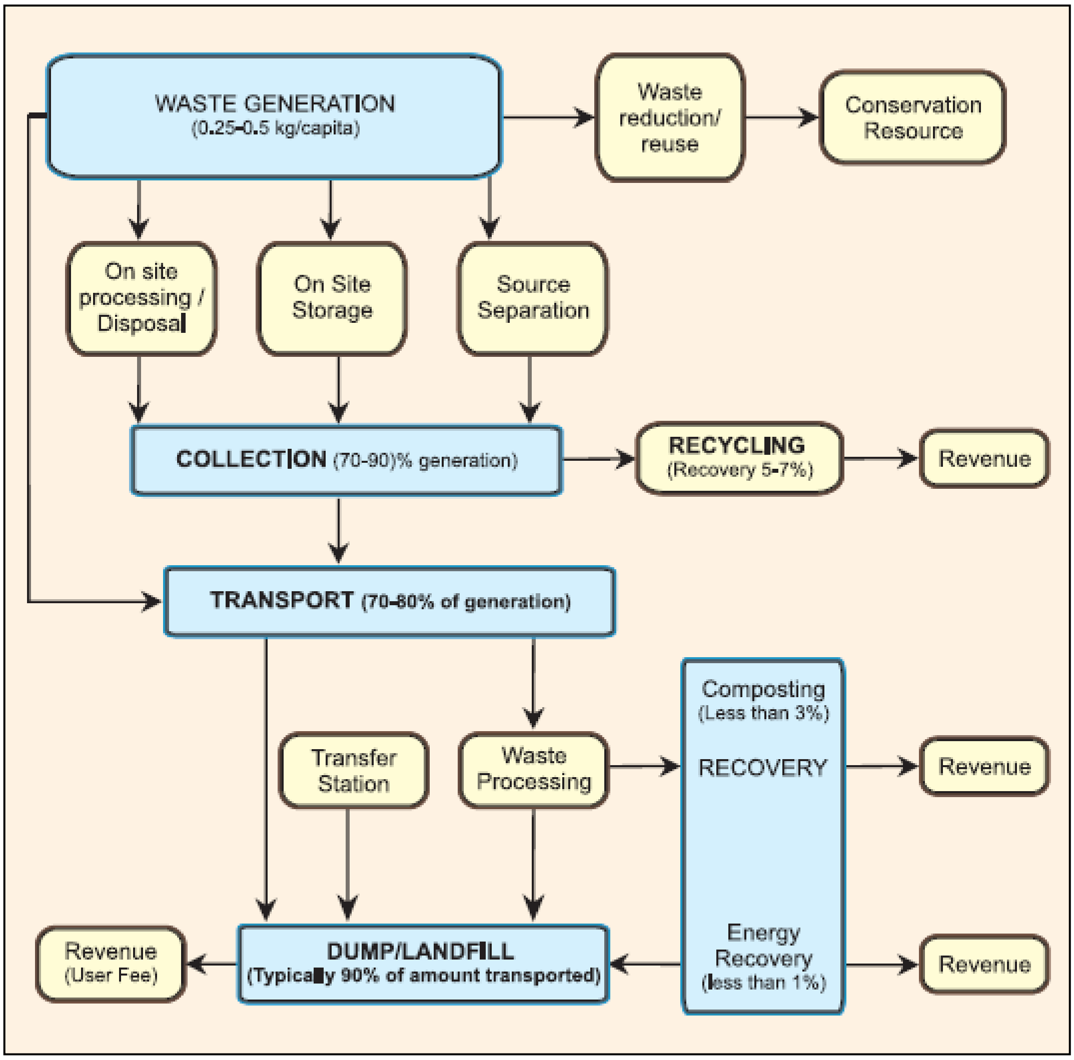

Figure 1.2: SWM flowchart for developing countries
(Source: (Hanrahan et al., 2006)).

Common expenditure-incurring SWM activities in developing countries are as follows (for a pictorial representation of the activities listed below, refer to Figures A.1 to A.14 in Appendix A; those are photographs taken during a field trip to India in 2010).

Waste collection- This activity includes collection of waste from community bins containing mixed wastes disposed by different types of users. Some countries practice storing wastes generated on-site (eg. at homes, on street sides) and wait for it to be picked up by service providers. This activity is commonly termed primary waste collection and includes door to door collection of waste by handcarts or tri-cycles and/or street sweeping. Primary waste collection is an activity that is generally not performed by service providers in developing countries, although in recent times, the activity is increasingly gaining recognition as an improvement over residents depositing wastes in neighbourhood community bins. Some developing cities also practice separating wastes into organics and inerts before waiting to be picked up, but this practice is very uncommon at present.

Secondary storage and transfer (intermediate activity, not shown in Figure 1.2)- This activity is associated with primary collection and happens where primary waste collection is performed. In the secondary collection system, wastes collected from the doorstep and from street sweepings are brought together at a designated storage and collection point that is within walkable distance for all waste collectors in a particular locality. From here wastes are sometimes transferred to a transfer station where they are loaded into larger vehicles. In other cases, wastes are collected from community bins and directly transported to a dumpsite without secondary collection.

Transport and unloading at dumpsite- The most common practice is to directly load open trucks with wastes collected at various secondary storage locations and unload them at the dumpsite . Alternatively, neighbourhood community bins can be lifted, placed onto a truck and unloaded at the dumpsite. If the system of primary and secondary services is followed, or even otherwise, sometimes the waste collected from a number of areas of a city is first unloaded into larger trucks at a transfer station, and then transported to a dumpsite for final disposal.

Processing and Treatment - Organic wastes are sorted for the production of compost that is used to improve soil properties. Composting is frequently encouraged in developing countries due to the high organic content in the wastes generated there. Some waste to energy treatments are also applied but such treatments have not proven to be successful due to the characteristics of wastes produced.

Recycling- A closer look at the PFD in Figure 1.1 and the activity chart in Figure 1.2 show that a waste management system can be broadly branched into two waste flowpaths. The first is for the material that ends up in a land disposal site; such sites are mostly large open dumpsites in developing countries. The second is the material that generates revenue and ends up in a market. In western systems, the two types of material are becoming increasingly better separated at source. In developing countries, although mixed at source, materials of value are ‘picked- out’ along the waste flow path. Recycling of waste is a major activity of the waste management system in developing countries. For example, in the study conducted by Scheinberg et al in (2010a), the six developing cities researched (with a total population of 23 million) had approximately 73,000 recyclers handling 3 million tonnes per year. However, this is an activity that incurs little or no expenditure, as it is mostly the business of service providers existing outside the formal system, i.e., the city's municipality. Hence, the term 'informal sector' is normally applied to waste recyclers in the developing world. Wilson et al (2012) reports that material recovery rates by the informal sector in developing countries can be as high as 85%. A number of references that discuss the activities and scope of the informal sector in developing countries can be found in a recent paper by Scheinberg (2012). For a detailed bibliography related to the informal sector in solid waste management, refer to the website of German International Co-operation or GIZ, formerly known as German Technical Cooperation or GTZ (http://www.giz.de, 2012).

1.3.2 Developing country challenges

Cities that are in the middle of the industrialisation phase are the ones that face the maximum number of challenges when providing the service (see Table 1.1). Most developing and transitional country cities come under this category.

Table 1.1: Reasons for poor functioning of solid waste systems in developing countries

Stakeholders	Problems
USERS/WASTE GENERATORS	• Number of people migrating to cities increasing exponentially • Higher incomes result in more waste generated per person • Handling weddings and religious festival wastes are an additional burden. Waste characteristics vary greatly depending on high, middle and low income areas • Separation of generated wastes (into organics, inerts and recyclables) at source generally not followed. Medical, industrial and other hazardous waste get mixed with municipal waste

SERVICE PROVIDERS	• A large number and wide variety co-exist, even within a single city (e.g. city municipality/ies, private contractor, community based, non-governmental and resident welfare organisations) • Illegal dumping into each other's territories • More focus on collection and less on treatment of wastes • Where source-separation efforts are made by residents,, waste collectors are not equipped to handle source-separated wastes.
GOVERNING AUTHORITIES	• Budget allotments on solid waste management depend on the ruling government's priorities • Frequent changing of governments and hence policies • Poor enforcement of policies • Corruption leads to inefficient provision of services

A number of researchers have already identified these problems and significant progress has been made in the last two decades to study the challenges of SWM in developing countries. Data on waste quantities and types are more readily available compared to before, and a number of books are published by organisations such as the World Bank, United Nations, Asian Development Bank and World Health Organisation that focus exclusively on developing countries. This collective effort in demonstrating both challenges and good practices using case studies examples have proven effective as decision-makers now seem to take more notice of the waste challenge that their city has been facing. This is evident from increased levels of spending on the service. For example, urban areas of Asia spent some 25 billion USD per year in 1998 (Zurbrugg, 2002).

1.4 Motivation

Despite increased spending on the service, finances are often a constraint in municipalities of developing countries. A number of issues in Table 1.1 are responsible for the financial challenges of the service. However, an important but unresolved technical concern is that service providers in developing countries often do not know how much it would cost to provide an improved or upgraded level of service (Diaz et al., 1999; Diaz et al., 1996; Diaz et al., 2005; Zhu et al., 2008). Information on actual costs, where available, is generally in the form of total costs of salaries, transportation and maintenance costs. More detailed information is hard to come by.

1.4.1 Cost estimation studies for developing countries

Few studies have been cited in available literature that venture into the topic of cost estimation for solid waste management. Notable ones focussing on developing countries are World Bank projects and include (1) a strategic planning guide (available online) for developing cities in transitional phase developed by Wilson et al (2001), (2) finance and cost recovery guidelines for the Middle East and North Africa by Faircloth et al (2005), and (3) cost yardsticks for Indian cities in the book by Zhu et al (2008). Wilson et al's(2001) work consists of a seven-step process that elaborates on alternative approaches to improving SWM; among these are cost alternatives for identifying and evaluating SWM options suitable to developing country conditions. Faircloth et al (2005) provides further guidance for detailed economic assessments of cost- effective alternatives suggested by Wilson et al (2001). The use of a discounted cash flow analysis is suggested by appropriate use of discounted rates and present values in order to calculate average incremental costs. This technique is useful to arrive at the least cost option for the best alternatives evaluated for developing countries. Zhu et al (2008) provides yardsticks that might be useful for Indian waste managers in estimating funds needed to improve service levels in the absence of good accounting data. The yardsticks are based on best practices from certain Indian cities, and using advice from experienced waste practitioners in the country. For example in estimating labour costs of going from community bin waste collection practice to the more effective door-to-door collection of waste, a yardstick of one collection worker per 1000 persons (or 200 households) is suggested. The wages for a full-time worker in 2006 Indian Rupees is 6000/month (1 US Dollar= 45 Indian Rupees in 2006). Knowing the population of the area to be serviced, collection costs for the improved level (i.e door-to-door) can be roughly estimated using the yardsticks prescribed by Zhu and co-authors. A more detailed review of the approaches used to estimate costs is provided in the next chapter of this thesis.

1.4.2 Improving cost estimation for solid waste management in developing countries

Most importantly, a solid waste manager does not have the means of analysing existing data into meaningful information that could be used to improve the efficiency of the service in developing countries. For example, information that could be of use to decision-makers are answers to questions such as 'how would cost vary with quantity of waste collected?', which are beneficial in deciding whether collective private waste collection is more cost effective than separately providing the service. Or say, in order to develop a financing strategy so that scarce financial resources could be used to the best effect, waste managers will need to know how waste management costs are influenced by output levels and other variables like frequency of collection, separation of waste as source, and informal recycling activities. Such strategies would need an understanding of the determinants of waste management costs, which are not well studied in a developing country context.

1.4.3 Objectives

The research for this thesis was conducted in a manner to allow new information to be quickly integrated, as problems with cost data required for such a project were anticipated in the early stages of the research. In that sense, the research operated without a task-based timeline, and instead was done in an iterative manner starting with coarse methods and refining them as information, time, and resources permitted. Specific objectives were not pre-set at the inception of the research undertaken, but were developed as the research progressed. The specific objectives are discussed in each contributing chapter of the thesis, and hence only the broad objectives are stated as follows:

- Review existing approaches used to estimate costs of SWM and select the most appropriate approach suitable for upgrading solid waste management in developing countries.

- Demonstrate the potential application of that approach by using a developing country dataset.

- Estimate the additional expenditure needed to provide a certain benchmark level of service in a developing city, and analyse reasons for overspending or under-spending.

- Examine other pathways for future research on this topic and provide advice on the type of data that needs to be collected for those analyses.

1.5. Thesis outline

The thesis is organised into 6 chapters. Chapters 2 and 3 are based upon refereed international journal papers published by the author and others during the course of this research, while Chapters 4 and 5 are being prepared for journal submission. A poster presentation and conference papers have also been made from this research. As per the new regulations of the University of Canterbury, details of journal papers published from this research is provided in the co-authorship form on pages vi-vii.

In chapters 2-5, an abstract of each chapter is provided along with concluding comments. In Chapter 2 the methods used for cost estimation for solid waste management for developing countries are reviewed with the aim to suggest an improved methodology. In Chapter 3 the potential application of the improved method is shown with the help of an Indian dataset, and experiences with that data are discussed. The complete dataset is available as an addendum from Page 250 of this thesis. This data is also downloadable from http://www.urbanindia.nic.in/theministry/statutorynautonomous/niua/swm.pdf.

Chapter 4 is an attempt to use the yardsticks prescribed by Zhu and co-workers in order to estimate costs for the provision of a benchmark level of service in the Indian city of Chennai. In Chapter 5, experiences from another public service, the healthcare sector, show the way for future cost estimation analyses for waste researchers. Overall conclusions from this research, limitations, and opportunities for further work are summarised in Chapter 6. Appendices, including a complete reference listing, conclude the thesis.

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CHAPTER 2: COST ESTIMATION FOR SOLID WASTE MANAGEMENT IN INDUSTRIALISING REGIONS: PRECEDENTS, PROBLEMS AND PROSPECTS

Abstract

The importance of cost planning for Solid Waste Management (SWM) in industrialising regions (IR) is not well recognised. The approaches used to estimate costs of SWM can broadly be classified into three categories- the unit cost method, benchmarking techniques and developing cost models using sub-approaches such as cost and production function analysis. These methods have been developed into computer programmes with varying functionality and utility. IR mostly use the unit cost and benchmarking approach to estimate their SWM costs. The models for cost estimation, on the other hand, are used at times in industrialised countries, but not in IR. Taken together, these approaches could be viewed as precedents that can be modified appropriately to suit waste management systems in IR. The main challenges (or problems) one might face while attempting to do so are a lack of cost data, and a lack of quality for what data do exist. There are practical benefits to planners in IR where solid waste problems are critical and budgets are limited.

2.1. Introduction

Perhaps the greatest SWM challenge faced by municipalities of IR is to achieve the most with limited funds. For example, a World Bank report on China (Hoornweg et al., 2005) on a lack of analysis into the "…cost-effectiveness in service delivery". A study of India (Hanrahan et al., 2006) highlights institutional/financial issues as the most important ones limiting improvements in SWM. Specifically, it notes that "There is an urgent need for much improved medium term planning at the municipal and state level so that realistic investment projections can be developed and implemented."

Cost estimation is a tool used to evaluate resource requirements while being aware of associated uncertainties (Ostwald and McLaren, 2004). Improving cost estimating for solid waste management improves decision-making in various aspects of the service such as contracting for new equipment, or when evaluating changes to operating and maintenance strategies (Milke, 2006). The traditional form of a municipal budget consists of separate cost estimates of recurrent revenue, operating expenditures, and capital spending (Schaeffer, 2000). An estimate in turn comprises various components of SWM, including salaries, equipment, and the costs of routine maintenance. High quality cost estimates for SWM can not only help establish budgets, but also help defend budgets when attempting to improve the level of service.

Cost planning for SWM has been discussed in various forms (e.g., user charges, economic analysis and economies of scale) for industrialised regions. Some have focused primarily on quantitative approaches such as programming, optimisation techniques, statistical methods, and cost-benefit analyses (Clark et al., 1971; Chang and Wang, 1997; Huang et al., 2001), whereas others have focused on a qualitative analysis of costs of specific processes such as waste minimization, privatization, collection and disposal (Palmer and Walls, 1997; McDavid, 1985; Strathman et al., 1995; Jenkins, 1991). For example, Wilson (1981) studied facility costs of waste disposal and suggested economy of scale factors for solid waste facilities. Porter (1996; 2002) emphasised the importance of focussing on solid waste economics while discussing ways to improve the service. Kinnaman and Fullerton (2001) compiled articles on the economics of residential SWM, including those that examine the external costs of municipal solid waste collection and disposal, the theoretical frameworks that can be used to model disposal decisions of households, and the empirical decisions that govern the selection of MSW policies. As an example application, the Seattle public utilities have developed a model called the Recycling Potential Assessment and System Analysis Model (RPA/SAM) to support several planning and policy initiatives (Bagby et al., 1998). The model uses previous cost estimates to forecast total system costs associated with SWM in Seattle.

Governments of IR are increasingly realising the importance of cost planning for SWM. For example, in India, the 12th Finance Commission (TFC) had recommended a grant of USD 550 million to Indian municipalities for the period 2005 to 2010 out of which at least 50% was set aside for SWM (Appasamy and Nelliyat, 2007). Funding agencies expect well planned budgets before the start of the financial year. These can be provided by a municipality only if the true costs of the service are determined by consolidating costs from all departments engaged in managing the waste within a municipality. Unfortunately municipal budgets of IR are mostly based on projections from previous budgets or the need to pay salaries and purchase supplies and very rarely does a municipality know the actual cost of providing the service (Diaz et al., 1996; Bartone et al., 1990). Municipalities of IR often complain about lack of funds. They feel like they are not in a financial position to meet community needs (Zhu et al., 2008).

Cost models from industrialised countries could serve as precedents in IR. But a methodology to estimate costs of waste management that is applicable to IR requires a clear understanding of the differences between the two levels of industrialisation (Table 2. 1).

Table 2.1: Differences between industrialised regions and IR in the context of SWM

Status	Industrialised	Industrialising
% Literacy	High	Low
Technology Level	High	Low
Per capita Income	High	Low
Social diversity and its effect on waste type	Low	High
Urban-Rural Divide	Low	High
Labour cost	High	Low
Capital Investment	High	Low
Quality of governance	Good	Poor
SW composition	Similar	Variable
Involvement of informal sector	Little /Nil	High

The Strategic Planning Guide for Municipal Solid Waste Management prepared for the World Bank by Wilson et al.(2001) gives a detailed step-by-step procedure for economic evaluation of SWM alternative strategies. An update of this work and extension of the financial chapters in the 2001 Strategic Planning Guide was prepared for the World Bank in the Middle East / North Africa region in 2005 by Faircloth et al. (2005). The finance and cost recovery sections of the guide contain tools, training material and case studies to aid municipalities and waste management agencies to effectively plan their finances. A book by UN- Habitat (Scheinberg et al., 2010b) is the most recent attempt to collect cost data along with other data and it compares 20 cities around the world. The book discusses in depth financial sustainability in SWM and its importance as a key governance feature. It looks at how the reference cities are counting costs and revenues, and how they are raising investments and managing their budgets. It is one of the few publications that reinforce the point made by the GTZ report (Scheinberg et al., 2010a)about the role of the informal sector (also referred to as scavengers or waste pickers (Wilson et al., 2006)) and its cost implications, a key difference between systems of IR and industrialised regions shown in Table 2.1. A summary of selected publications that have reported costs of SWM from IR is presented in Table 2.2.

Table 2.2: Costs of SWM from IR

Reference	Selected Case study locations	US$/tonne (except where noted)	Year of reported costs	Costs of Formal (F) or Informal (I) sector
Scheinberg et al (2010b)	Belo Horizonte, Brazil Delhi, India Quezon City, Phillipines	89/tonne 39/tonne 11/tonne	n.a	F
GTZ/CWG (2007)	Cairo, Egypt Cluj, Romania Lusaka, Zambia	13/tonne(F), 4/tonne (I) 35/tonne (F), 7/tonne (I) 173/tonne (I), 7/tonne (I)	2006-2007	Both
Hanrahan et al (2006)	India	18/tonne – 36/tonne	2003	F
Koushki et al.(2004)	Kuwait	24/ tonne	n.a	F
Metin et al (2003)	Turkey	5/capita – 13/capita	n.a	F
Do an and Süleyman(2003)	Istanbul, Turkey	35/tonne	2001	F
Agunwamba et al (1998)	Onitsha, Nigeria	10/ tonne	1991	F

Note: n.a. – not available

The objective of this paper is to review current practices used to estimate costs of SWM in IR. If suitable precedents were not available from IR, examples are drawn from industrialised countries. The common problems facing a SWM planner in IR are discussed thereafter. An understanding of these problems suggests prospects for improved cost planning in IR.

2.2 Precedents

2.2.1 Unit Cost Method (UCM)

In the UCM, each activity (namely collection, transportation, treatment and disposal) is disaggregated into separate items such as salaries, consumables, fuel costs, and maintenance costs. Next the required quantity of each item is noted. Multiplying this with the cost per item or unit cost (developed from existing datasets or taken from price quotes), the total cost of each item is calculated. The overall cost of the service is then calculated by summing the total costs incurred by each item. The method can be used for setting up a new facility, buying additional resources, or used for budget preparations.

Table 2.3 shows the cost estimate developed for the state of Rajasthan (India) to improve SWM services in its 183 municipalities (Asnani, 2006).

Table 2.3: Capital cost estimate for modernisation of SWM in the state of Rajasthan, India, in 2006.

Source: (www.almitrapatel.com/docs/132.doc, date of citation 23-03-2011.) (1 USD = 45 Indian Rupees in 2006).

Item no.	Item of Expenditure	Estimated Quantity	Unit Cost in Millions of Rupees(MRs)	Estimated cost in (MRs)
1	Public awareness	-		10.00
2	Capacity building	-		5.00
3	Containerized tricycles & wheelbarrows	15000	0.009	135.00
4	Secondary storage			
	7 m3 containers	1000	0.04	40.00
	2.5 m3 containers	2300	0.015	34.50
5	Transport vehicles			
	7 m3 hydraulic container-lifting truck	97	1.4	135.80
	2.5 m3 hydraulic container-lifting truck	97	1.1	106.70
	Tractor with hydraulic container-lifting device	140	0.75	105.00
6	Road sweepers	19	2.75	52.25
7	Construction of transfer stations	200	*	133.40
8	Large containers for transfer stations	50	0.15	7.50
9	Large hauling vehicles	30	2	60.00

10	Construction of compost plants		177	**	511.35
11	Engineered landfills				
	Large Landfill	40 Hectare	1	50	50.00
		16 Hectare	1	20	20.00
	Medium Landfill (20 acre)		11	10	110.00
	Small Landfill (10 acre)		58	5	290.00
12	Management Information System (Improved accounting system using GIS, pro-formas for collecting cost information)				0.50
	GRAND TOTAL				1807.00

* The cost of transfer stations in the state of Rajasthan in 2006 prices @ 0.5 MRs/municipality in the130 municipalities having populations < 50000, 0.8 MRs/ municipality in the 39 municipalities having populations between 50,000 and 100,000 and 1.2 MRs in the 14 municipalities having populations > 100, 000, amounts to 113 MRs. The O&M cost is estimated at 20.4 MRs amounting the total cost to 133.40 MRs.

** It is estimated that the cost of construction of a compost plant excluding the cost of land would be 5MRs per 100,000 population. Towns having population < 100,000 lac should opt for vermi-composting at 6.25MRs for a design population of 100,000

The UCM to estimate costs of SWM is simple to prepare, is reliable due to its top down approach and is easy to understand. The method being a deterministic approach to cost estimation means that the independent variable(s) are more or less a definitive measure of the item being estimated and hence this methodology is not subject to significant conjecture (Christensen and Dysert, 2003).

Although the method is straightforward in principle it can be laborious in application. The UCM requires robust documentation so the quantity of each cost component is reliable. The level of detail in decomposing into tasks will vary considerably from one estimate to another. If used for forecasting, it requires a good estimate of the number of units that will be required. Proper documentation can be difficult due to problems of poor accounting procedures and changing conditions of a city.

In addition, the UCM faces many difficulties because of its reliance on appropriate unit costs. Inflation can be easily overlooked with the UCM, and must be accounted for. The UCM assumes that cost data are available and complete, which is not always true, and incomplete cost data sets can lead to biased estimates. Furthermore, variability in unit costs may arise because different standards are required within a system (eg, daily collection in commercial zones, alternate day collection in residential zones), and these variations often need close consideration when developing cost estimates.

Cost contingencies are hard to estimate and could easily increase the uncertainty of a cost estimate prepared using the UCM. Examples include lower than actually quoted labour rates, corruption costs from bribes paid to inspectors and officials to overlook shortcomings and associated penalties (Coffey and Coad, 2010).

Overall, the reliability of the method is a function of the reliability of the cost model. Because of the complexities in modelling large systems, other methods can provide more readily accessible guidance on costs. Nevertheless, because of its simplicity and clear assumptions, the unit cost method is the most commonly used method to estimate costs of SWM worldwide.

2.2.2 Benchmarking

A quick way to make a reasonable cost estimate is to use actual cost data from a similar organization that has made a change of the type under consideration—this is commonly called benchmarking. The Department of Urban Services, Canberra, Australia in their 1999-2000 budgets have used benchmarking analysis to estimate costs of waste management and recycling. To estimate landfill costs in the 1999-2000 budget, comparative information has been taken using the 1998-99 budget information from a similar jurisdiction (www.treasury.act.gov.au, date of citation-23/03/2011) In another report, the Vermont Department of Environmental Conservation's Solid Waste Program (DSM, 2005), used the data from the residential and commercial price survey findings in 1999 to estimate the total solid waste and recycling collection and disposal costs for planning purposes in 2005. The 1999 data served as a benchmark cost and were used for comparison of SWM prices statewide and by region, and is also expected to serve as a benchmark for future comparisons.

The World Bank report by Hanrahan et al (2006) summarizes the findings of a year-long analytical work conducted by the World Bank, in two Indian states and three hill towns. To improve understanding of costs of MSW management, a spreadsheet was modelled in collaboration with municipal staff in the study locations. Also presented in the report are approximate expenditure benchmarks across municipalities (1 USD= 45 Indian Rupees (INR) in 2006)

- Collection of waste: 300-400 INR/tonne
- Transport of waste: 300-400 INR/tonne
- Treatment/disposal (average costs, excluding land): 400-600 INR/tonne
- Total cost of waste collected and disposed: 1000-1200 INR/tonne

Due to difficulties in normalizing the data obtained from different cities, costs were reported in ranges and individual cities were not identified. (Hanrahan et al., 2006).

Benchmark costs need to include all costs. The UNEP's (2004) 'Introductory Guide for Decision-makers' mentions that the total annual costs, i.e. operating cost plus the annual payback for capital investments, should be estimated since collection equipment, landfills and other installations needed in an integrated waste management system have various lifetimes and depreciation periods. It suggests estimating costs separately for general administrative initiatives (such as issuing permits, legislation), and specific waste processing activities (such as recycling, composting) for different waste streams (such as putrescible, organic or inorganic, recyclable and non-recyclable, hazardous). According to the authors, this should make it possible to keep track of the economic costs of reaching objectives. It may also make it possible to compare the costs of the existing waste management system with the future costs of the new waste management plan(UNEP, 2004).

Benchmark costs can be reported on a per capita, per mass, or per volume basis, and there can be difficulties in applying these to new situations without more information. For example a benchmark collection cost of $30/tonne could be for a waste with a density of 300 kg/m3 and generated at a rate of 0.1 tonne/person-year. However, in many IR, densities of collected waste can reach 600 kg/m3, and a generation rate of 0.2 tonne/person-year (Diaz et al., 1996) would imply the same volume of waste collected. Because of this, normalised benchmark costs should also provide values for tonnes/person-year and waste densities to ensure appropriate comparisons are made.

As an example of the use of benchmarks, Zhu (2008) provides benchmarks (Table 2. 4) for assessing the needs of funds for Indian SWM services. Their book provides advice to improve costing and budgeting of SWM services. For example, for waste collection a common existing system involves having concrete street bins as central collection points, to which individual householders take their waste. To estimate the cost of an upgrade to door-to-door collection, one would use the benchmarks provided in Table 2.4.

Table 2.4: Benchmarks for estimating costs of SWM in India (Zhu et al., 2008) (Prices in 2006; 1 USD= 45 Indian Rupees (INR) in 2006)

Door to Door Collection One containerised tricycle/handcart per 1000 persons. Cost of Tricycle: INR 6500 –7500 (Inclusive of containers); Handcart: INR 4000 – 5000 ; Handcarts and Tricycles have a useful life of 3-5 years). One sanitation worker to cover 200 houses /shops in 4 hours serving a population of 1000 each day (Labour costs for one full time worker is INR 6000 per month). One part time supervisor per 25 sanitation workers. (Labour costs for one part time supervisor is INR. 3500 to INR. 4500 per month per worker).

Street Sweeping

Each street sweeper to be given individual containerized handcart / tricycle (for costs see above).

One person per

300 to 350 meters of road length (in High Density Areas)

500 to 600 meters of road length (in Medium Density Areas)

650 to 750 meters of road length (in Low Density Area)

Labour costs same as D-T-D collection.

Secondary Storage

Provide a pair of metallic containers (one for organics collected from households and the other for street sweepings) of 3.0 m3 -7.5 m3, with four containers per square km of the city area or one container per 5000 - 7500 population. (A 3 m3 will cost INR 19-20,000 and 7.5 m3 will cost INR 45,000).

Transportation

1 vehicle per 10 containers (Costs of container lifting vehicle is INR 1 million for 7 m3 containers and INR 850,000 for 3 m3 containers ; a smaller tractor with container lifting device costs INR 525,000).

Additional 25-30% for standby vehicles.

One driver and one sanitary worker per vehicle (Labour costs= INR 6000/month for a full time worker or INR 3500/ month for part time worker.

Processing/ Composting

INR 12 million for populations under 50,000.

INR 20 million for populations up to 100,000.

INR 34 million for populations up to 200,000.

Disposal in an engineered landfill

Capital cost of INR 100- 150 per cubic metre (includes construction cost, weighbridge, office accommodation).

Operating cost of INR 200- 1100 per metric tonne of waste depending on size of landfill.

Benchmarks might not allow fair comparisons. A lack of full-cost accounting is one potential limitation, and capital costs could be neglected in some benchmark costs. Inadequacies in the database (such as no year of the costs) may mean that this approach should not be used. Limitations can exist because the scope or quality of services provided could vary greatly. Even without these issues, the costs associated with a specific item (eg, a landfill) are site-specific, reflecting availability of local facilities, salaries and land prices . There could be bias in a dataset that would cloud the value of its use. A budget may have been under accounted to make it look good for easy approval of funds or it could be over accounted for managers to show at a later stage that they performed well by cutting costs in the long run.

A lack of reliable information on costs can be exacerbated if responsibility for the different waste management tasks is spread widely across a number of divisions. This is a particularly large issue in IR where both the informal sector and non-profit organisations can be operating in addition to the municipality in SWM, and so are not considered by a municipality when developing benchmarks. The savings to the municipality by these other sectors is hard to estimate and so adjustments of benchmarks based on a municipality's data is challenging. The only attempt at reporting benchmark figures of informal sector costs in IR is the report by GTZ/CWG (Scheinberg et al., 2010a); the reader is referred to section 2.3.2.1 for more discussion. Costs of other such smaller organisations if overlooked have potential to cause serious discrepancies when using benchmarked values for cost planning purposes.

Another issue with the benchmark technique is potential bias in the dataset. A budget may have been under-accounted to make it look good for easy approval of funds or it could be over-accounted for managers to show at a later stage that they performed well by cutting costs in the long run. Such biased costs, if used as benchmarks to estimate costs elsewhere, could lead to serious deficiencies in long term planning. Data issues related to cost estimation for SWM are discussed further in Section 2.3.

The use of benchmarks assumes that they represent good practice, and that the location under consideration should manage solid waste following this exemplar. This can lead to the difficulty that the estimated cost reflects what the community should spend and not what they do or will spend. Hence even though benchmarking costs of SWM is one of the most common approaches, it is unreliable if not done with appropriate quality assurance systems. The systems being compared need to be understood in terms of their characteristics such as the individual components of a system and the standards under which they operate.

2.2.3 Cost Modelling

2.2.3.1 Production and Cost Functions

Economists refer to the relationship between the output of a process and the necessary input resources as a production function (Fullerton and Kinnaman, 1995; Wohl and Hendrickson, 1984). The amount of output is the maximum, or best, output achievable for a given set of acceptable inputs. For solid waste management, a production function would relate the specific factors that a manager could use to provide the service, for example, number of trucks and number of employees. The term cost function is used to describe more broadly the relationship of cost to variables. Cost functions relate the cost of solid waste management to production factors or to variables such as population density or the type of service provided (door-to-door or community collection).

Cost and production functions can be expressed in terms of a variety of input variables (trucks, employees, frequency of collection, total tonnes collected), and can be either linear or non-linear functions. If the only input variable considered is a scale variable, such as tonnes/year, then the function describes the economy-of-scale effect for that cost. The effect can show increasing returns of scale where negatively-sloped, constant returns to scale where horizontal and decreasing returns where positively sloped (Figure 2.1). The coefficients in cost and production functions are typically estimated empirically based on the use of regression techniques applied to available data sets.

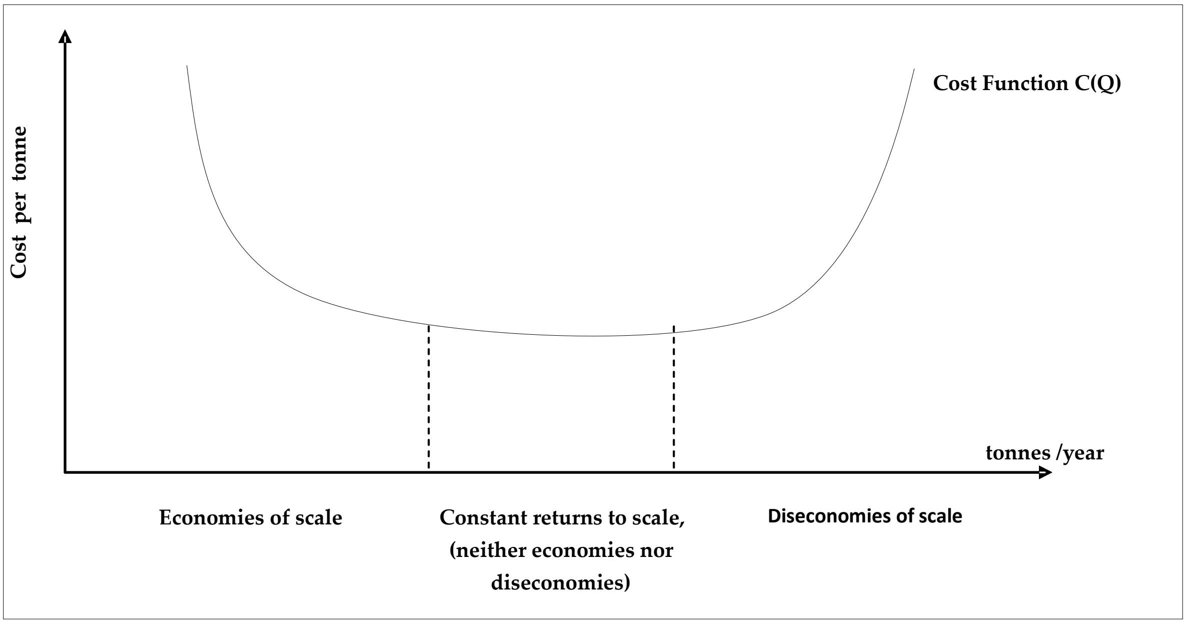

Figure 2.1: Returns to Scale (Increasing, Decreasing and Constant)

Cost and production functions have a number of uses. They help a planner in evaluating performance at one location by allowing comparison. They allow for future predictions such as examining the cost implications of increasing the frequency of waste collection from once to twice a day. They allow one to draw conclusions concerning economies of scale. They can be used to find what set of inputs will minimise system costs for a given level of service.

Moreno-Sanchez and Maldonado (2006) built upon their earlier works and performed a numerical simulation using production functions for waste pickers using data from

Bogota in Columbia. Their results were aimed at suggesting optimal policy instruments like consumption tax, recycling subsidy and extraction tax to help policymakers in incorporating the informal sector into the formal waste management system. Although no other instances of cost or production functions for IR were found in available literature, there have been a number of applications of cost/production functions to industrialised country settings. The Ramboll/COWI Joint venture (2002) has applied average cost functions to arrive at SWM investment options at the regional level in Poland. They estimated cost functions for different waste treatment facilities (such as windrow composting, biogas plant, MRF, recycling, incineration, landfills etc) applicable to Europe. The values used to arrive at these cost functions have been obtained based on experience by COWI and information from various facilities. The cost functions are in the form y= m(xi)b where y= total investment or O&M cost; m and b = constants; xi= design/actual capacity (in tonnes per year). Callan and Thomas (2001) present an economics literature review of solid waste disposal and recycling services in industrialised countries. Based on their specification of costs, they employed Zellner's(1962) seemingly unrelated regression (SUR) procedure to estimate a two equation cost function model. D. Pangiaotakopoulos and co-workers have been active in developing functions relating the cost of particular solid waste processes (eg, landfills) to size (Kitis et al., 2007; Tsilemou and Panagiotakopoulos, 2004 ; Tsilemou and Panagiotakopoulos, 2006). This appears to be the first work on economy-of-scale factors for SWM since that of Wilson (1981).

Early researchers such as Hirsch (1965) presented residential refuse collection cost models. A number of variables were analyzed using production functions and cost functions. Multiple regression and correlation techniques were applied to 24 municipalities in the St Louis City-County area in 1960 (Hirsch, 1965). The data did not reveal significant scale economies but the authors commented that it cannot be considered conclusive, mainly because municipal and collection area boundaries may not have coincided in all cases.

Clark (1971) suggested a stepwise regression analysis approach as a planning tool for arriving at cost functions for metropolitan SWM in 20 Ohio municipalities. A total of eight variables hypothesized as having an influence on cost were analyzed. The study concluded that financial arrangement (i.e., who pays for the service), collection frequency and pickup location (curb or back of house) are the only significant factors affecting costs of collection. The effect of population density and waste collected per unit areas were not considered in the analysis. Economies of scale were not investigated in this study.

Stevens (1978)analyzed the costs of waste collection using data of 340 public and private firms collecting refuse in the United States during 1974-75. These were analysed for population ranges lesser than 20,000, 30-50000 and greater than 50000. The author first formulates a production function Q=A LαKβ where Q is the total quantity of refuse collected; A is a constant representing the state of technology and the joint effect of a set of variables influencing the production process (such as weather conditions) which must be held constant in a cross section study; L is the total quantity of labour inputs; K is the total quantity of capital inputs; and α and β are distribution parameters representing the share of output attributable to labour and capital, respectively, and where 0 < α, β <1. The objective was to estimate the total costs of refuse collected at households as a function of market structure, refuse per household, the frequency and location of pickup, population density and variation in temperature. It was concluded that strong economies of scale in refuse collection exist only for communities up to 50,000 in population. This author's discussion of how production functions give rise to neoclassical economic cost functions is a particularly good introduction for readers who may not be immediately familiar with the neoclassical economic theory of the firm and of market structures.

The most recent works by De Jaeger and co-workers (De Jaeger et al., 2011) and Weng and co-workers (Weng and Fujiwara, 2011) feature cost estimation methodologies using cost and production functions. The authors recommend using the data envelopment analysis technique and the econometric modelling technique respectively to handle growing complexities and uncertainties in modern waste management systems. For more industrialised country examples on cost function analyses for solid waste management using multivariable regression analysis the reader is referred to the article by Bel and Mur (2009) which contains a concise review of existing literature on the topic of cost functions for SWM.

2.2.3.2 System Models

A number of models focus on economic aspects and their main purpose is to minimise costs using linear programming or other optimization techniques. The advanced optimization modelling framework developed by Xu et al. (2010) uses a combination of existing linear programming and optimisation methods to appropriately balance uncertain aspects of the waste management decision process. To demonstrate the applicability of their method a hypothetical SWM case of three municipalities was chosen, and two treatment options (landfilling and incineration) were evaluated, to arrive at a long term cost planning model.

The purpose of the Local Authority Waste Recycling Recovery and Disposal (LAWRRD) model (Brown et al., 2006) is to estimate the minimum local waste management costs throughout England, along with the flows of materials and the facilities needed for waste treatment to meet the EU Landfill Directive targets and increased rates of recycling and recovery. LAWRRD is a costs-driven model that takes each administrative region, finds its minimum cost system subject to various constraints, and then aggregates overall costs. It models waste management by taking input data on waste production, numbers of actual or planned facilities from each local authority in turn and then summing the relevant outputs to develop a picture representing England as a whole.

The GIGO program developed at UC Davis aims to minimise SWM costs in a wide variety of locations of industrialised regions (Anex et al., 1996). Similarly, FEASIBLE (a freeware that can be obtained through the web pages of the OECD (www.oecd.org, date of citation: 23-03-2011), DEPA/DANCEE (www.mst.dk, date of citation: 23-03-2011) and the developers, COWI Ltd. (www.cowi.dk, date of citation- 23-03-2011)) was developed to support municipal solid waste, water and wastewater financing strategies for the European Union, Central and Eastern Europe and the former Soviet Union. FEASIBLE uses built-in cost functions (referred to as ‘expenditure functions’ in the software’s user manual), developed by COWI, to generate investment, operating, and maintenance costs. These are based on scenarios or inputs describing the existing physical infrastructure and the future physical infrastructure, and applied to selected case studies (Pesko et al., 2003)

The COSEPRE (costs of urban cleaning services) program developed by Sandoval et al (PAHO, 2001) allows cost evaluation of scenarios and facilitates the calculation of the annual and unit costs per service, based on information provided by the user. It determines the costs of each service only when a complete full cost accounting is already available to the user.

There are a number of review papers on SWM models which summarise the current work in this field (Beigl et al., 2008; MacDonald, 1996; Morrissey and Browne, 2004), hence this approach is not discussed in detail in this paper. None of these advanced methods have been tested and validated for industrialising countries.

One major challenge when using system models is the difficulty in generalising them to other situations. It can be difficult to obtain the underlying cost functions, and even more difficult to know how they have been developed and their potential applicability. More significant for this review is an acknowledgment that the values used in industrialised countries are so removed from circumstances in IR (Jain et al., 2005; Rathi, 2006) as to be unusable. Future research is needed to analyse the values used by various models relevant to industrialised countries.

2.3 Problems

IR use either the UCM or benchmarking approach to estimate costs of SWM. Both these approaches rely heavily on good cost data. A common woe cited in the literature on SWM in IR is the lack of cost data for high quality planning (Agunwamba et al., 1998; Hoornweg et al., 2005; Visvanathan and Trankler, 2003; Idris et al., 2004). Although none of the authors in the available literature have thoroughly examined the topic of data limitations with respect to SWM, they state that data issues compound the difficulties of decision making and modelling. Cost estimation and planning needs to be informed by past data.

The objective of this section is to review the challenges that planners need to overcome while attempting to estimate costs of SWM in IR. An Indian case study is studied as an example as it well represents the complex nature of waste management systems of a typical IR due to its economic, social and cultural diversity.

2.3.1. Data Analysis

The National Institute of Urban Affairs in India (NIUA, 2005) conducted a study in 1999 to assess the status of water supply, sanitation and SWM in roughly 300 selected cities and towns in India and estimated the funds required for full coverage of population by these services in the urban areas of the country.

Figure 2.2 shows that cost per person varies widely with population in India; no trend can be observed and economies of scale do not seem to exist.

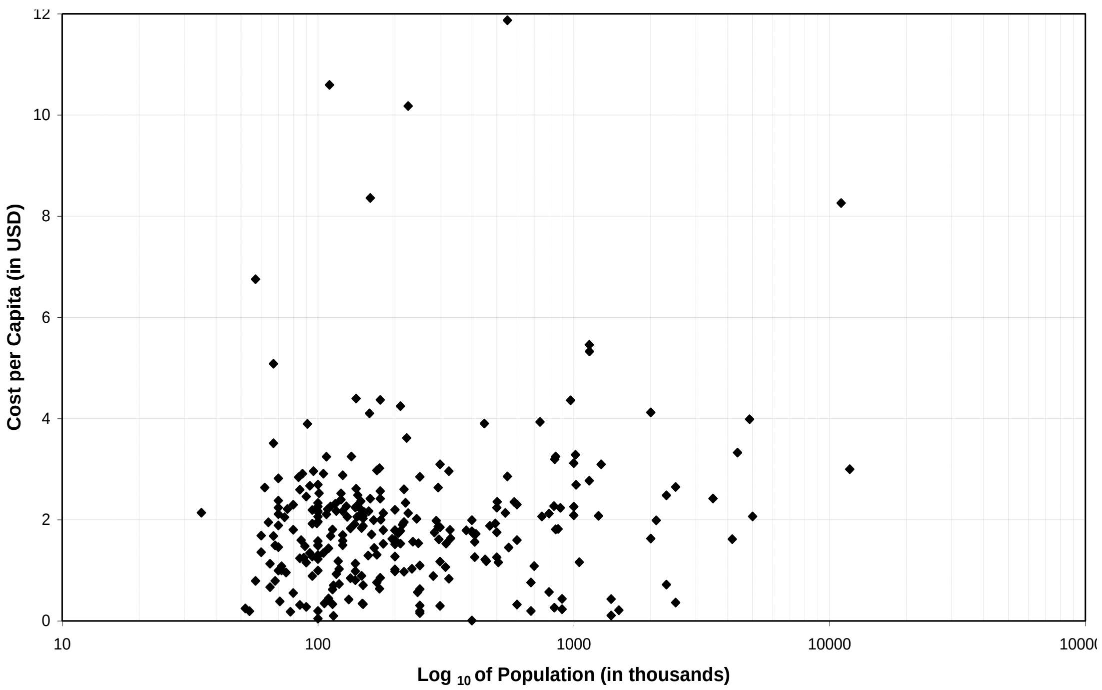

Figure 2.2: Graph of population vs. cost/person, India 1999
(Data Source: NIUA (2005))

The above example was from a single source hence it was decided to cross-check the validity of the data from other sources. Table 2. 5 gives a comparison of the per capita expenditure on SWM across select cities, from different sources.

Table 2.5 : Per capita expenditure in Indian Rupees (INR) per annum on SWM from various Indian sources (1 USD = 45 INR in 2006)

City	FICCI*	NIUA**	NSWAI***
Delhi	431	135	497
Mumbai	428	372	392
Jaipur	301	185	301
Chennai	295	150	295
Ludhiana	258	73	1

*FICCI -Federation of Indian Chambers of Commerce and Industry (FICCI, 2007) (Population estimate-2001 census, year of cost not documented but assumed here to be same as population estimate)
**NIUA - National Institute of Urban Affairs (NIUA, 2005)(Population and Cost in 1999)
***NSWAI - National Solid Waste Association of India (www.nswai.com, date of citation: 23-03-2011) (Population estimate as per 2001 census, year of cost not documented but assumed to be 2001)

2.3.2 Data Issues

The data values are estimated in Figure 2.2 and Table 2.5 are arrived at using either the UCM or benchmarking methods, or a combination of both. The joint impact of the following data issues is the probable cause of variability associated with SWM data shown in the figure and the table.

2.3.2.1 Variety in scope of service

SWM in India involves a complex mixture of various organizations. The formal ones include municipal organizations and private contractors. In addition, there are non-governmental organizations (NGOs), community based organizations (CBOs) and resident welfare organizations (RWOs) that employ the informal sector to carry out this activity. Finally, there is an independently working informal sector that can collect waste and participate in resource recovery, sometimes without payment, and outside of normal methods of data collection.

Wider scope amounts to greater confusion when cost data are presented. At first glance, at say the city of Ludhiana in Table 2. 5, it would seem that only one source has rightly reported the city's per capita costs, and two source must be in error. But in fact it is possible that each source has reported costs of a different organization involved in managing Ludhiana's waste, thus making comparisons misleading. For example, the highest cost of INR 258/capita reported by FICCI could be the overall cost collated for both formal and informal sector. Whereas the cost reported by NIUA (INR 73/capita) is known to be the cost incurred by the formal sector only i.e, of the municipality and its private contractor (NIUA, 2005).The cost reported by NSWAI of INR 1/capita is possibly the cost incurred by the municipality alone, i.e., excluding costs to private contractor and informal sector. A planner looking to predict costs for an estimated population of 5 million for Ludhiana will not be able to choose the best cost per person estimate between the three sources in Table 2.5 unless he/she has a clear understanding of all the organizations involved in managing Ludhiana's waste.

Another issue confronting a SW planner is that the scope of activities can vary from city to city. The cost per capita is arrived at by dividing a municipality's net cost of collection through disposal by the population it services. Comparing the cost per capita values, it is quite possible that one city has a compost/landfill facility, which incurs a higher net cost than a city that open dumps its waste.

Sometimes, the scope of SWM activities varies within the same city. Consider the example of Delhi in Table 2. 5; the areas that are covered by the New Delhi Municipal Committee of Delhi have door-to-door collection, while the areas covered by the

Municipal Corporation of Delhi bring their waste to community bins ((Scheinberg et al., 2010b). The mixed system in Delhi could have an effect on the net cost (which in turn affects average cost per capita) making it lower compared to Chennai which has completely adopted door to door collection in all its areas.

An issue with cost data on SWM from IR is that they are generally available as municipality SWM expenditures or percentages of overall municipal budget (Scheinberg et al., 2010b). Costs of private contractors are not well documented. Getting cost data on the informal sector is even harder due to their flexible and informal systems of operation. The only attempt at providing cost information about the informal sector available in the literature is the report by GTZ/CWG (Scheinberg et al., 2010a) which finds that the overall system costs or costs per tonne would rise in developing counties if not for the informal sector recycling activities. The cost per tonne of waste operations (mainly collection and operating costs) of the informal sector vary from 3-90 Euros/tonne in the six cities of IR analysed in the report. The figures reported are a useful start to future studies regarding informal sector costs and also allow for comparison with the formal sector.

2.3.2.2 Variety in quality of service

Costs of SWM are best analyzed when divided by some metric, usually tonnes or number of persons (DPPEA, 1997). Differences in quality of service could have an effect when using normalizing metrics. A potential problem that could affect the proper evaluation of per capita costs in Figure 2.2 is the large uncollected parts of the city. For example, let us assume that the cost per capita for servicing a city was 2.07 USD in 1991, found by dividing an expenditure of 10.35 million incurred on SWM in 1999 by the municipality, by a 1991 census population of 5 million. But if the municipality had actually serviced only half the city's population, i.e., 2.5 million and not 5 million in 1999, the cost per person served would have been 4.07 USD. Supposing that the incorrect value of 2.07 USD/ person were used to estimate costs for an extension of service to an extra 1 million population, the budget could be underestimated by 2 million USD.

Similarly, if costs were measured on a per tonne basis, a potential problem affecting costs per tonne could be that the parts of the city where waste are not collected are also the parts where it is expensive to provide services, possibly underestimating the true costs per tonne if the whole city were to be serviced.

Getting a good measure of the amount of waste collected and the population serviced are crucial data needed to estimate costs in a consistent form. Even after accounting for parts of the city serviced, a distinction is needed between costs per tonne generated and costs per tonne collected or disposed. The UN-Habitat book (Scheinberg et al., 2010b) showed that 16 out of 20 cities that were surveyed diverted a minimum of 65% of waste going to their formal disposal sites, due to informal sector recycling. This can have an effect on the cost/tonne collected or generated which is useful for planning purposes, and has potential to distort cost estimates.

2.3.2.3 Differences in cost accounting systems

A number of sources in literature (Hanrahan et al., 2006; Scheinberg et al., 2010b; Wilson et al., 2001; Zhu et al., 2008; Metin et al., 2003; Zurbrugg, 2002; Schübeler et al., 1996; Idris et al., 2004; Bartone et al., 1990; Wilson, 2007) discuss fuzziness in cost accounting procedures as a major issue limiting improvements in SWM in IR. One example is whether or not equipment purchase is accounted for as a capital cost or an ongoing depreciated cost. Others are if costs are before or after tax, and whether costs of overheads, operating costs, fuel costs ,benefits to employees are included or not. A final example relevant to the NIUA dataset is the definition of 'salary and wages'. Under this component if one municipality accounted for certain expenses such as reimbursement of medical expenses, welfare expenses, uniform, payment to casual staff, travel concession, and hospitalization benefits, adding 20% more to its 'salary and wages' component, the overall cost per capita could easily be higher compared to another municipality that did not report these costs as part of its 'salary and wages' component. Differences in accounting systems are not always clear and can make it difficult to compare costs between organizations.

The Strategic Planning Guide for Municipal SWM prepared for the World Bank by Wilson, Whiteman and Tormin(2001) and an update of this work for the Middle East / North Africa region in 2005 (Faircloth et al., 2005) note that municipalities of IR are not able to clearly distinguish cost components (capital, operating, O&M) in accounting data. The guidelines suggests that recurrent costs incurred through operating municipal SWM should include 1) direct operational expenditures such as wages and maintenance 2) provisions for accrued expenses and liabilities such as employee pensions, obligations, insurance and 3) annual amortization charges to recover the capital assets over their useful life such as loan interest and depreciation (ELARD, 2005)

2.3.2.4 Cost adjustments

Too often in literature the year in which costs are documented is not mentioned, making comparisons difficult, like in the case of Table 2.5 in which the year of costs were not clearly reported by NSWAI (www.nswai.com, date of citation: 23-03-2011) and FICCI (2007).

When the year of reported costs is known, there is always a need to adjust costs obtained to account for inflation for one currency, and to account for the variation in value between currencies. For example, in Figure 2.2, to arrive at costs per capita, the 1997-98 SWM expenditure of the municipalities from the NIUA report was brought to April 1, 1999 (the start of the financial year in India) prices using rates of inflation from the Labour Bureau, Government of India, to make it consistent with the population estimate provided in the report. An approximate exchange rate of 1USD =INR 45 in 1999 was assumed. Choosing an appropriate exchange rate for cost comparisons that best accounts for differences in SWM prices between countries can be a challenge. It is often unclear what an appropriate currency exchange would be when IR sometimes have strict currency exchange rules. Also, when exchange rates vary depending on what was bought or sold (multiple exchange rates), particularly on capital goods such as high end trucks used to transport waste, it is hard to select a particular exchange rate. Another approach would be to use the 'purchasing power parity' or PPP exchange rate as it converts the data into a common currency and values it at the same price levels, making the process of cost comparisons between countries simpler . PPPs are estimates derived from the relative price levels in different countries and reflect the rate at which currencies can be converted to purchase equivalent goods and services (Vachris and Thomas, 1999). For example, if the PPP exchange rate is 9.3 Indian Rupees per USD, the average monthly wage of a collection worker in India which is 6000 Indian Rupees in terms of its purchasing power in India, is equivalent to 645 USD. If this is to be compared to a Chinese collection workers salary of 800 Renminbi (with PPP exchange rate 1USD is equivalent to 3.462 Renminbi), the equivalent in USD would be 231. Although using the PPP exchange rate is not so common and is currently being used for topics concerning poverty issues, it seems a valuable alternative when cost comparisons for SWM are concerned.

2.3.2.5 Scarcity in public domain

The UN-Habitat study (Scheinberg et al., 2010b) is a recent wide-ranging attempt to collate SWM data (financial and other) for 20 cities on a comparable basis. It is acknowledged that such an attempt was difficult. The NIUA (2005) work is another example, but there appear to be no other studies, which reflects the scarcity of SWM data. The NIUA study took 10 years to complete because of issues such as election schedules, non-response to questionnaires by municipalities, and follow-up required for incomplete data (NIUA, 2005). In IR, municipal websites do not give sufficient information on the costs of projects undertaken. Overall, financial matters are rarely discussed in the public domain.

The United Nations report (Habitat, 2001) states that "one of the key challenges faced by municipalities of IR is to reduce corruption". One might speculate that inaccessibility of cost data could also be due to municipal authorities fearing that the discrepancies of the system (corruption, low wage rates paid for labor) could be exposed if such information becomes accessible or published.

2.4. Prospects

Studies indicate that local conditions, management strategies, composition and characteristics of SWM are similar in IR. (Zurbrugg, 2002; Diaz et al., 1999; Beede and Bloom, 1995; Savage, 1998), Better cost estimation for SWM could lead the way to creating a SWM database with country- specific unit cost estimates, similar to what has been developed by WHO (World Health Organisation) researchers (Adam et al, 2002) for healthcare management, another public service with characteristics similar to SWM (Cossu, 2011a).

Improved cost accounting in municipalities of IR has the potential to improve cost planning. Unfortunately as critical as this activity is, cost estimation of SWM must frequently be done without the benefit of good historical data or adequate sample sizes. In such cases one could attempt to study a similar locality, city or town which is managing its waste well, and develop benchmarks from its experience to estimate costs (Zhu et al., 2008). Activity-specific cost functions could be developed from a series of well chosen benchmarks.

Hybrid cost estimation methods attempt to combine aspects of benchmarks with aspects of the unit cost method. For example, the informal sector study of Scheinberg et al. (2010a) estimates costs by developing a series of cost components based on activities, and then developing a complete set of the number of each unit used. Rather than rely on estimated local costs as would be done under a pure UCM, they use benchmark unit costs based on their previous experience in IR. There is further potential to improve cost estimation methods by using selective benchmark values, rather than gross cost benchmarks (eg, cost/ton, or cost/capita-year).

Developing cost functions for SWM will be central to improved cost planning for IR. It would help in making cost comparisons between cities, in predicting future costs, and identifying key variables affecting costs. While regional differences and technologies yield different average costs, the way in which production functions, and consequent cost functions, are modelled is invariant across regions. The lack of cost functions for SWM was highlighted by Pearce (2005) as a significant hindrance to improved efficiency. This is even more critical in IR where problems of waste are severe and finances are constrained. A step by step development of cost function for SWM using an Indian case study can be found in Parthan et al(2012b). Further research is needed to manage the differences between regions, and the quality of data, within cost models developed using cost functions.

Few advances have been made in estimating direct monetary costs of SWM in IR. When such estimates are available, they can be used as inputs to deterministic analysis methods, such as calculating net present value or internal rate of return, as suggested by the Environmental Resources Management's (ERM) Strategic Planning Guide for SWM designed for the World Bank (Wilson et al., 2001).

New methods for cost planning will support waste managers when faced with difficult decisions (Milke, 2006). Improved cost estimates would lead to easier cost accounting and so fewer misspent resources, leading to an improvement in service delivery in IR. More importantly, it would increase the confidence of national governments and aid agencies that an investment of financial resources will be spent well. Development of better cost planning for industrialising regions has the potential to open the door to creative systems for improving SWM there, much as carbon accounting has allowed carbon trading systems between industrialised and IR. Such schemes would require a high quality system for estimating costs to achieve specific performance levels, which does not now exist.

2.5. Conclusions

The number of publications on cost estimation and planning for SWM with specific reference to IR is limited indicating that much more attention needs to be paid on this topic. The examples of data issues provided for IR indicate the nature of challenges faced by a SWM planner and are not intended to criticize the system.

A good cost planning approach for SWM is one that allows for improvements in SWM practices to achieve a certain level of performance while efficiently using available data and financial resources. In IR the performance level is governed by how well an increasingly migrant urban population is being covered by the service. The usability of existing cost estimation methods for SWM cost planning seems limited for two reasons. First, each method (UCM, benchmarking and cost modelling) has its drawbacks when applied to IR. Second, the underlying complexities resulting from multiple stakeholders involved in managing waste in IR (municipalities, private contractors, non-governmental organisations, community based organisations, resident welfare organisations, informal sector) makes cost estimation difficult.

An integrated approach that combines the potential of the UCM, benchmarking technique and cost modelling approach using cost functions could be a way towards improving cost planning in IR. A recommendation would be to firstly map out the flow of material and costs, through different stages and including all providers, in the existing SWM system (along the lines of a process flow diagram as suggested by Scheinberg et al (2010b). Cost functions based on the unit cost method for each stage in the system could then be developed. This could help determine existing costs or rates, which would most likely be different for different providers of the service in IR., for example, with informal recycling, there is the income to account for. These costs or rates could be used as future benchmarks and could also be useful to compare with benchmarks from other cities. The developed activity-wise cost functions could be aggregated into an overall system model. Such a model when calibrated for geographic areas where there are good data could be used for municipalities or areas with limited data. In addition, development of cost models may assist in understanding data deficiencies.

An improvement in cost estimation and planning in this very important public service could greatly help in upgrading existing systems in a cost efficient manner during a process of industrialisation. There is great potential for innovative publishable research on the topic, and high long-term research impact can be expected in addition to the important practical benefits.

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CHAPTER 3: COST FUNCTION ANALYSIS FOR SOLID WASTE MANAGEMENT: A DEVELOPING COUNTRY EXPERIENCE

Abstract

The need for improved cost planning methods for solid waste management (SWM) is particularly strong in emerging economies where problems are severe, expectations for improvements are high, but finances are constrained. Estimating cost functions is suggested as an improved cost planning method. The research uses 1999 data from 298 Indian municipalities, covering over 140 million people. Stepwise multiple regression involving eight predictor variables was conducted on costs to detect any statistically significant correlations. The average costs on either a per tonne or per capita basis are most influenced by the total number of staff employed per capita or per tonne. The results are believed to be due to labour costs being such a high fraction of total costs in developing countries. Due to high variability in labour intensity between municipalities the data showed no clear correlation between per tonne or per capita costs and population, indicating no economy-of-scale. The data used here are subject to significant conjecture over their quality and age; however, the unique nature of the study should help future researchers investigating costs in emerging economies.

3.1 Introduction

Few advances have been made in estimating direct monetary costs of SWM, in spite of many publications emphasising the importance of understanding the 'true costs' of the service in developing countries (Cointreau-Levine, 1994; Diaz et al., 1996; Parthan and Milke, 2009; Parthan and Milke, 2010; Scheinberg et al., 2010b; Zhu et al., 2008).

Current cost estimation approaches used in developing countries generally follow the unit cost method, example in Asnani(2006), which disaggregates each activity (eg, collection, disposal) into separate items (eg, salaries, fuel costs), noting the required quantity of each item, multiplying this with the cost per item or unit cost (developed from existing datasets or taken from price quotes) to arrive at the total cost. Knowing the population of an area or the total waste collected in an area, the average costs per capita or per tonne are calculated. To predict future investment needs, these per tonne or per capita values from the unit cost method are multiplied by the projected quantities of wastes or population. There are three problems with these conventional cost estimating methods. One is that these rough estimates do not help compare costs between cities, which would help in noticing particular cities that have developed better and efficient practices. Secondly, it does not allow analysis of the factors that influence costs on a per person or per tonne basis. Thirdly and most importantly these current approaches do not particularly facilitate upgrading of solid waste practices, for example, estimating the cost associated with expanding the use of door-to-door collection in place of community bin collection; issues of such nature are commonly encountered by rapidly growing economies. New methods for cost planning will support waste managers when faced with difficult decisions (Milke, 2006).

Waste planners in the developed world increasingly use cost functions to avoid limitations of the unit cost method. A cost function is the relationship between the dependent variable which is costs, and one or more independent variables affecting costs. The variable coefficients are best estimated using regression analysis, a statistical technique. Porter (2002) in his engaging book on the economics of waste shows how cost functions can be used by society to make decisions that are economically efficient. Developing cost functions for SWM has a number of advantages. They can help a planner in evaluating performance of different locations by allowing comparison (Clark et al., 1971; Hirsch, 1965; Stevens, 1978). They allow for future predictions such as examining the cost implications of increasing the frequency of waste collection from once to twice a day (Bagby et al., 1998; DANCEE et al., 2003b; DANCEE et al., 2003a; Ramboll/ COWI Joint Venture, 2002). They allow one to draw conclusions concerning economies of scale (Callan and Thomas, 2001; Stevens, 1978; Wilson, 1981; Tsilemou and Panagiotakopoulos, 2004 ; Tsilemou and Panagiotakopoulos, 2006). They can be used to find what set of inputs will minimise system costs for a given level of service (Stevens, 1978).

The need for developing SWM cost functions is particularly strong in developing countries since problems of waste are critical but finances are limited (Milke, 2006). The need for cost functions as an improved cost planning method is well understood in another type of public service- healthcare management. This is evident from the many publications on the topic, even on developing countries (Riewpaiboon et al., 2008; Wagstaff and Barnum, 1992). The World Health Organisation cost project(WHO-CHOICE) has involved assembling publications, tools and standardised methods for cost estimation, and establishing regional databases or country-specific unit cost estimates using the cost function methodology (Adam et al., 2003) .

Since no previous attempts to perform a SWM cost function analysis have been published for developing countries, the objective of this paper was to arrive at cost functions for a typical developing country dataset while stepping through the method previously used to arrive at cost functions for developed countries.

3.2 The Indian NIUA Dataset

It is rare to have large datasets available for SWM cost function analysis. A previously unanalyzed but comprehensive developing country dataset that presented this unique opportunity of performing a cost function analysis was from the National Institute of Urban Affairs (NIUA, 2005) in India. Statistical volume III of the NIUA (2005) report covered a sample of 298 cities and towns out of almost 700 districts in India, with a total population of over 140 million people. The statistical volume is available as an addendum from Page 250 of this thesis. This data is downloadable from http://www.urbanindia.nic.in/theministry/statutorynautonomous/niua/swm.pdf.

The sampled cities and towns have been divided according to the following population ranges- Metropolitan Cities(population> 1,000,000) [n=22], Class I cities (100,000 < population< 1,000,000) [n=164], and Class II towns (50,000< population< 100,000) [n=112] according to the 1991 Indian census to correspond with degree of urbanisation or industrialisation. The NIUA Class II data also includes six towns with a population of less than 50,000. These are the capitals of the relatively small states and union territories and have been merged with Class II towns to avoid a fourth classification of towns with a very small sample size. The three ranges seem to describe distinct MSW management practices based on their differing average waste generation rates of 0.5 kilograms/person/day in metropolitan cities, 0.377 kilograms/person/day in class I cities and 0.297 kilograms/person/day in Class II towns.

Costs provided in the NIUA (2005) report are the expenditures incurred on SWM for the year 1997-98 by individual municipalities; over 75 per cent of these reported costs constitute expenditures incurred on salary and wages by individual municipalities (NIUA 2005). Data on annual waste collected in tonnes is also provided. Unless otherwise stated all data is from the year 1999. Other data are provided for: population and area served (in km^2), transportation vehicles and number of trips made per day, amount of waste transported in tonnes, quantities of waste disposed and composted (in tonnes), landfill details on area and future life, total number of staff employed by the municipality, costs spent on private contracts in Indian Rupees (reported by 24 out of 298 municipalities), revenue receipts in Indian Rupees in 1997-98, capital works undertaken between 1994-99 and future capital works proposed by each municipality.

3.3 Steps in Estimating a Cost Function

3.3.1 Selecting scale-free cost/dependent variable

Figure 3.1 indicates that waste collected per person per year varies from 0.02 to 0.27 tonnes in India. Note that both population and waste data estimated for the year 1999 from the NIUA report have been considered in Figure 3.1. A full interpretation of this figure is not possible without understanding the limitations of the data as described in sections 3.3.2 and 3.4.3.

Inferences from costs correlated with population and costs correlated with waste quantity could be different. Hence two cost analyses are performed in this paper- one with *cost per capita* (**CPC**) and the other with *cost per tonne* (**CPT).**

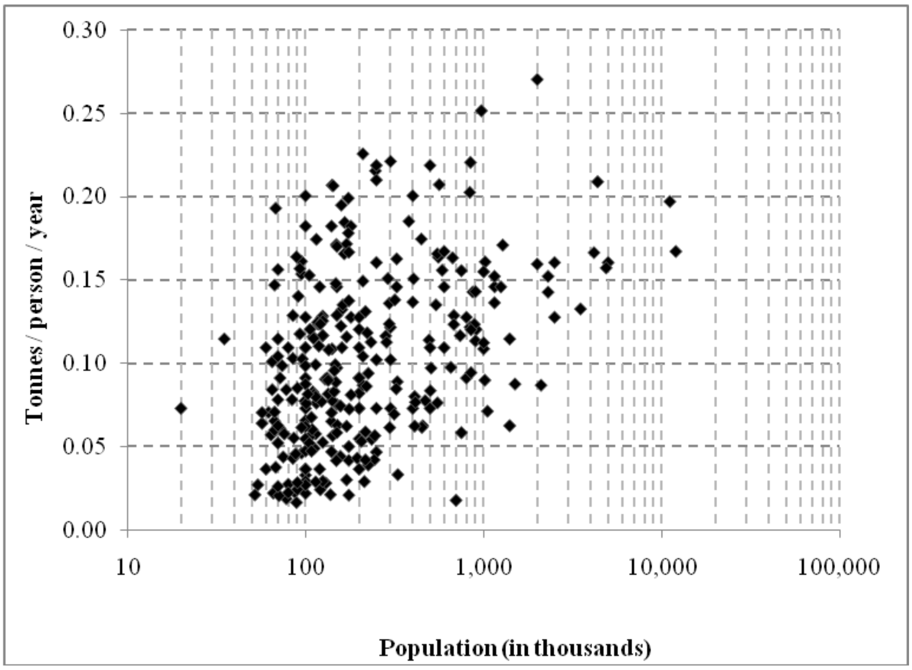


Figure 3.1: Variation of waste collected person^{-1} year^{-1} with population (n=298; NIUA, 2005)

CPC is actually CPC per year but will be referred to as CPC in this paper for the sake of convenience. The authors have adjusted the total SWM expenditure provided for the year 1997-98 in the NIUA report to April 1, 1999 (the start of the financial year in India), using rates of inflation from the Labour Bureau, Government of India, and an exchange rate of 1USD = 45 Indian Rupees in 1999.

3.3.2 Selecting independent variables

Since no previous developing country literature was available to provide guidance on choosing appropriate cost determinants, selected socio-economic variables, for which information was available from the NIUA report, and which were presumed to have an effect on the dependent cost variables, are considered in this analysis. The following brief description of these variables indicates why or how they are determined. All these variables are applicable for the year 1999 to be consistent with the year for which total costs are computed.

Population Density (number of persons km^{-2}) (x_1): This is obtained by dividing the estimated population by the estimated area (in square km), both data obtained from the NIUA report. One might expect the CPC to be lower for cities that have higher population densities because of lower transport costs. On the other hand, it is harder to collect waste from densely populated areas in India (Coad, 1997) which negatively affects the efficiency of the collection worker.

Waste collected per unit area or WPA (tonnes km^{-2}) (x_2): WPA was measured as a ratio of waste collected per municipality and the estimated area (in sq km). In the absence of weighbridges, the local governments give an approximate figure for waste collected. One might expect the CPC to be lower for cities with higher waste per unit area. If other non-municipal organizations, such as non-governmental organizations (NGOs) and community based organizations (CBOs) share the responsibility, it is expected that the municipality's costs per person will reduce; hence the effect of this variable on costs per person is studied.

Number of vehicles used for transportation (x_3): This was obtained by adding the number of motorized and non-motorized vehicles used for SWM in a city or town. Although not stated, we assume that the total includes out-of-service vehicles, because the NIUA study indicates that an average of 15% of vehicles are out of service at any given point of time (NIUA, 2005). The depreciation, fuel and maintenance costs for a large number of vehicles can contribute significantly to the total costs of SWM for a municipality, and inefficient vehicle use would be expected to correlate with higher overall costs. This variable was normalized to give a variable on a per person basis, and also normalized to give a variable on a per tonne collected basis.

Average trips per vehicle per day (x_4): This is the average number of trips made by both motorized and non-motorized vehicles to transport waste from community bins and transfer stations (if any) to specified dumping sites. The NIUA dataset does not give the trips per day for each vehicle size; still, the cost should generally be expected to increase when the trips per vehichle per day decrease. When these 'legal' dumpsites are situated far away from the city, the number of trips per day made by each transportation vehicle decreases, and the cost increases. This variable could show inefficiencies in waste transportation that are reflected in total costs.

Total number of staff employed (x_5): SWM activities are highly labour intensive in India. The salaries or wages of the municipal staff employed contribute anywhere between 10-70% of total costs (Zhu et al., 2008). The data used here are the sum of the supervisory and sub-ordinate staff employed in the SWM sector. This variable was normalized by dividing by either the population or the tonnes year^{-1} collected as appropriate.

Frequency of collection (x_6): Collection frequency contributes to collection costs which in turn affects the total costs. Since the minimum and most frequent collection is once daily in most municipalities across the country, it has been classified as a categorical variable; taking the value 0 if waste is collected once daily and 1 if it is collected more than once. Roughly 14% from the metropolitan sample, and 40% from the Class I and Class II sample of the NIUA report were reported to have collection more than once per day.

Privatization (x_7): Certain activities such as collection, disposal, and transportation, are privatized in certain municipalities by contracting them to formal private firms. Privatization is being encouraged in the SW sector in India as it has been observed to reduce average expenditures (NIUA, 2005). Hence this was included as an independent categorical variable that takes the value 0 if no activity of SWM is privatized and 1 if some aspect is privatized. Costs from the NIUA report exclude those of private organisations working under contract to municipalities. Roughly 43% from the metropolitan sample, 78 % from the Class I sample and 88% from the Class II sample of the NIUA report have not privatized any of their SWM activities to a private firm, meaning that the service is managed by the municipality alone.

Medical waste collected and disposed separately (x_8): Medical wastes, as per Indian law, have to be collected and disposed separately (NIUA, 2005). But in reality it has been observed that very few cities actually collect and dispose of them separately (NIUA, 2005) perhaps fearing the additional cost that they might incur. Hence the effect of this variable on total costs was studied. This was classified as a categorical variable taking the value 0 if it is not collected and disposed separately and the value 1otherwise. Roughly 28% from the metropolitan sample, 17% from the Class I sample and 16% of the Class II sample of the NIUA report were reported as not collecting and disposing their medical wastes separately.

Basic statistics of the variables with and without population divisions are summarized in Table B.1 of Appendix B

3.3.3. Development of cost functions

Estimating cost functions requires a statistical tool that measures the average amount of change in the dependent variable associated with a unit change in one or more independent variables while taking all observations into consideration. Regression analysis allows one to best estimate the parameter values or constants in a cost function and has thus been used by previous researchers conducting cost function studies for solid waste management (Chang and Wang, 1995; Clark et al., 1971; Tsilemou and Panagiotakopoulos, 2006; Hirsch, 1965). Linear regression was conducted using SPSS 17 software. Stepwise regression was used to evaluate correlation. This method involves finding the best predictive variable, then controlling for its effect, and finding the next best predictor, and so on. This has the advantage of reducing the impact of co-linearity between predictive variables. In addition, the stepwise method seemed defensible in this study as no previous research of this nature was cited in the available SW literature for developing countries on which to base specific hypothesis for testing. A pre-set condition in stepwise regression procedure was that those variables below a significance level of 0.05 (p value associated with the t-test) would not be considered as statistically significant and would be automatically excluded from the model (Field, 2009).

Variables that are highly correlated with another explanatory variable cannot be considered independent and should be excluded. Scatter plot matrices can be useful if correlations are high (Mukherjee et al., 1998), but for this intensely scattered dataset they were not of much help. Hence a correlation matrix that gives correlations between all pairs of variables in a dataset was developed. A Pearson's correlation coefficient was found and tests for significance conducted. A value of 0.7 or more was considered a strong association between independent variables indicating that both variables were measuring the same phenomena and that one of them could be eliminated. It was decided that the independent variables having a higher correlation with the dependent variable will be retained and the other will be excluded in the next part of analysis. The strongest correlation was between two candidate independent variables, namely population density (x_1) and WPA (x_2), indicating that one might be derived from the other in certain cases. Nevertheless unless a correlation ≥ 0.7 was reported, both variables were used in the stepwise regression.

Outliers had a strong effect on the results in this study. Those municipalities having unusually large differences between observed and predicted values (i.e., large regression residuals), are considered potential data outliers. *Standardized residuals* are residuals after they have been constrained to a mean of zero and a standard deviation of 1 (Field, 2009).

Those municipalities having a standardized residual less than -3 and greater than 3.0 were defined as outliers. Outliers were removed individually, and the remaining dataset checked for further outliers. The total number of outliers removed is listed in Table B.2 of Appendix B.

3.4 Results and Discussion

3.4.1 Cost Function Analysis

The cost functions developed are presented in Table 3.1 (statistical details are in Appendix B). The total number of staff, x_5,plays a significant role in every population range. More staff per tonne or per capita, is correlated with higher per tonne or per capita costs. This highlights the observation in SW literature that the service is highly labour intensive in developing countries and that major costs are salaries of staff (NIUA, 2005; Zhu et al., 2008; Hanrahan et al., 2006). Thus the higher the number of staff employed per tonne or per capita, the higher the per tonne or per capita costs are. Because a large fraction of costs are labour costs, the high variability in costs per capita and costs per tonne indicate large variations in labour costs even after normalizing by population served or waste collected.

Table 3.1: Approximate cost functions for SWM in India

Population Range	Cost functions
Metropolitan	$CPC = -1.80 + 1.160x_5 + 39.623x_3$ $CPT = 4.60 + 858\ x_5$
Class I	$CPC = 0.88 + 0.470\ x_5 - 0.37\ x_7 + 0.029\ x_6$ $CPT = 7.03 + 1.829\ x_5 - 4.248\ x_7$
Class II	$CPC = 0.74 + 525\ x_5$ $CPT = -3.00 + 2.080\ x_5 + 0.0009\ x_1$
Without population divisions (All data included)	$CPC = 0.662 + 0.491\ x_5 + 0.071\ x_2$ $CPT = 7.46 + 1.786\ x_5$

N.B- Metropolitan Cities(population> 1,000,000), Class I cities (100,000 < population< 1,000,000) , Class II towns (50,000< population< 100,000); Dependent Variables- cost per capita(CPC) and cost per tonne (CPT**);** Independent variables- x1=Population Density, x2= Waste collected per unit area, x3=No. of vehicles used for transportation, x4=Average trips per vehicle per day, x5=Total number of staff employed, x6=Frequency of collection (0=once daily, 1=more than once daily), x7=Is some aspect privatizated ? (0=NO, 1=YES), x8= Is medical waste collected and disposed separately? (0=NO, 1= YES)

At first glance, the hypothesis that other variables such x_3, x_7, x_6 and x_1 are useful in predicting total costs of SWM seems reasonable. But their relative importance when compared with x_5 shows that they are weakly significant in cost predictions of SWM. Because they are not common throughout these analyses, the other variables that do occasionally appear are likely to result from spurious correlation.

3.4.2 Observations on economy-of-scale effects

Table 3.2 gives the average predicted costs for the three population ranges and for the whole dataset irrespective of city size. Although there does seem a slight increase in the average CPC with increase in city size and also a small decrease in average CPT with an increase in city size, there is no strong trend. The question arises- is there a benefit in considering different population ranges while analyzing costs of SWM?

Table 3.2: Predicted Costs with and without population divisions

	CPC		CPT	
Population Range	No. of Cities	Average Predicted Cost (in USD)	No. of Cities	Average Predicted Cost (in USD)
Metropolitan cities (Above 1 million)	21	2.63	21	15.68
Class I cities (Between 0.1-1 million)	141	1.77	137	18.59
Class II cities (Between 0.05- 0.1 million)	93	1.68	93	27.99
Total Sample	229	1.80	255	21.53

In addition to Stevens (1978), the World Bank report by Hanrahan et al (2006) divides cities into population ranges while evaluating costs. For comparison the CPC and CPT from the World Bank report were presented as ranges as shown in Table 3. 3.

Table 3.3: CPC and CPT for three population ranges in India

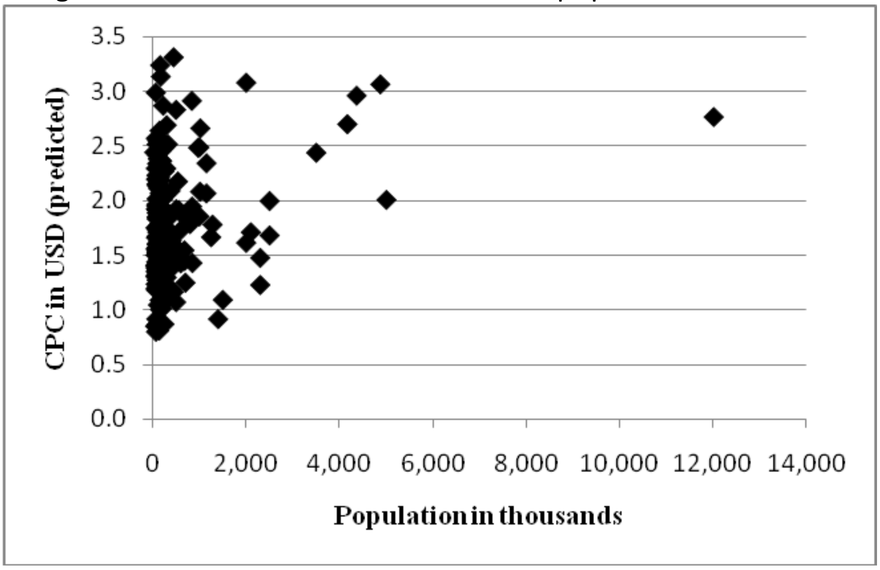
(Source: Hanrahan et al., 2006; 1 USD approx= 45 Indian Rupees in 2006)

Population Ranges	CPC per annum (in USD)	CPT (in USD)
Large Cities (Above 1.5 million)	3.67 – 3.89	20 – 26.67
Mid size Towns (Between 0.5-1.5 million)	3.33 - 4	17.78 – 26.67
Small Towns (less than 0.5 million)	2.67- 3	17.78 – 35.56

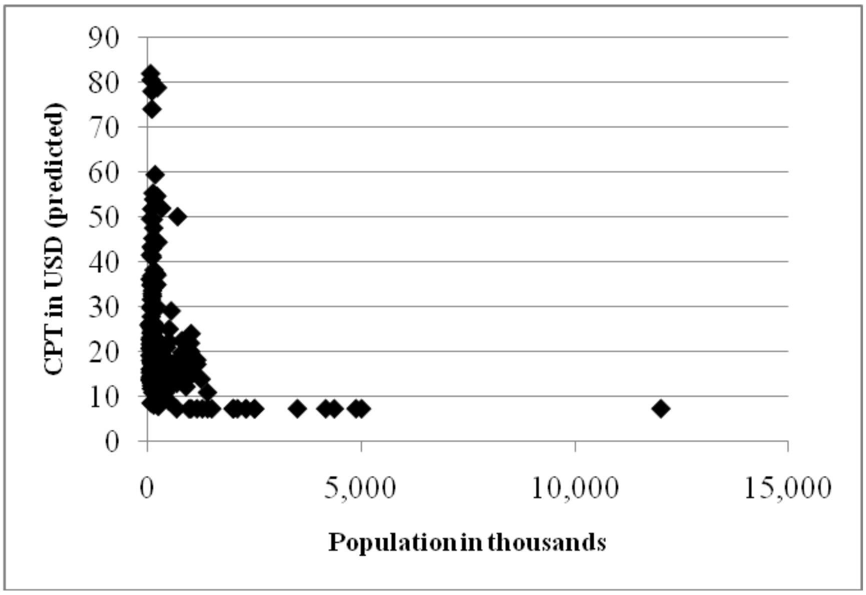
The values in Table 3.3 show some trend between unit costs and population range indicating a possibility that economies of scale exist (Hanrahan et al., 2006).

The results of our study also indicate that more populous urban areas do not incur higher costs per person or costs per tonne for their SWM service than less populated cities. Figure 3.2 shows a lack of a clear trend when plotted against population, while Figure 2.2 shows a similar lack of trend when plotted against the log of the population. As shown in Table 3.1 and irrespective of population ranges (or city size), the total number of staff employed per person and per tonne is the single most important factor affecting unit costs of municipal SWM. High variability in labour intensity between municipalities within population ranges could be the reason that no trend could be established between unit costs and population in Figure 3.2 (a & b). Despite including privatization in the analysis, which could have potentially reduced distortion resulting from the variability in labour intensity, there was no indication that economies-of-scale existed.

Figure 3.2: Costs correlated with overall population



(a) CPC versus population



(b) CPT versus population

3.4.3 Data Limitations

The results of this study should be used with caution. For example, while calculating costs per person the correct population serviced by the municipality in 1999 was not known and instead the 1991 census population was projected to 1999. SWM in India is highly decentralized and is known to be managed by various agencies other than the municipality of the city. As per the NIUA report, a certain population of the city could be serviced by private agencies, some others by NGOs, some by community-based organisations, some by a public-private partnership and so on. This shared responsibility varies from one city to another (NIUA, 2005). This might be one source of error while calculating CPC causing it to be lower than actual. In the absence of weighbridges, a potential source of error that causes CPT to be higher than actual is that the actual waste collected may be estimated from assumed volumes at the waste disposal sites; the actual waste quantities collected being reduced by informal recycling that happens all along the SWM pathway. The potential for large uncollected parts of the city could also affect the proper evaluation of per capita costs. A potential problem affecting costs per tonne could be that the parts of the city where waste are not collected are also the parts where it is expensive to provide services; possibly underestimating the true costs per tonne if the whole city were to be serviced.

Unfortunately proper documentation of an extensive SWM database like that of NIUA (2005) in developing countries is often a challenge and even if such data are available, it may be subject to serious conjecture (Parthan and Milke, 2009). The reliance of the cost function approach on good cost data could be seen as a strong motivation for SW managers of developing countries to further improve their accounting procedures.

3.5 Conclusions

It is rare to have a comprehensive cost dataset such as the one published by the NIUA (2005) in emerging economies such as India .The results from this study show the potential, and limitations, of performing cost function analysis for SWM from developing countries. The models suggested here must be used with caution as the equations in Table 3. 1 are not a perfect fit to the data. Also, there are a number of sources of uncertainty and error such as doubts about accuracy and precision of the data. Cost evaluation of SWM, generally done on a cost per person basis or cost per tonne basis, requires good estimates of the population serviced and good documentation of the amount of waste collected by the organization that handles it. It is acknowledged that there are a number of organizations that manage wastes in developing countries and that maintaining a good SWM database can be a daunting task. In spite of these limitations, the analysis indicates strong evidence in support of the importance of the number of staff employed per capita as a cost estimator for developing economies such as India.

Dividing into population ranges, which is commonly done during cost estimation of SWM activities in India, appears to be neither necessary nor useful. Nevertheless more analysis is required to understand the correlation of unit costs and population. Further research should include an integrated system that takes into account the cost implications of other small organizations operating alongside a municipality that employs the informal sector. These organizations play a significant role in performing the service in developing countries such as India, hence not taking such organisations into account can cause serious deficiencies while developing cost functions for SWM.

Similar complexities and variabilities from developing countries have not hindered research in the healthcare management sector to advance cost function analyses. That example indicates how a similar concerted effort could benefit solid waste management.

The cost function method and results are presented for the Indian SWM scenario in this paper, but with the great diversity included within such a large country, the results should extend to other developing counties. It is hoped that the methodology suggested here will be a useful start, and further study on this aspect is stimulated for those working in developing countries.

3.6 References

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CHAPTER 4: COST ESTIMATION FOR SOLID WASTE MANAGEMENT IN AN URBAN DEVELOPING CITY AND APPLICATION TO CHENNAI, INDIA

Abstract

A common problem faced by urban cities of the developing world is to estimate how much it would cost to improve solid waste management (SWM) to handle increasing populations, waste types, or to raise the level of service. Multiple stakeholders and service providers increase the complexity of this problem. Planners will often be faced with three important cost questions – (1) how much will it cost to ensure a certain benchmark level of service? (2) is the city currently spending more or less than the predicted costs? and (3) what are the marginal and average total costs for waste collection and disposal as the city grows? Cost data that were available from Chennai, a typical urban developing city in India, are used as an example of how one would answer these questions. To answer the first question, cost benchmarks associated with SWM activities were calculated using yardsticks suggested by Zhu and co-workers in their World Bank publication 'Improving Municipal Solid Waste Management in India'. These benchmarks are compared with actual expenditures from Chennai's formal service provider. The result was that actual costs match up well with the predicted costs in Chennai's case. To answer the second question, a cost curve was developed using cost and waste quantity data based on existing city limits. Economies of scale are estimated across all waste quantities. The potential application of the cost curve is demonstrated by using it to estimate costs in areas outside the Chennai city limits that are

becoming potential nodes for city expansion. Although this study was limited to the formal sector servicing the developing city, the method could be applied to cost estimation studies for other large cities in developing countries, by (1) using more cost determinants, (2) including the informal sector, and (3) extending the approach to source separation and reduction programmes.

4.1 Introduction

As people migrate to cities in industrialising regions, significant increases occur in populations in districts surrounding the existing urban cities that have little or no good infrastructure. Major Indian cities such as Delhi and Chennai have been experiencing this phenomena in the recent past. As a result the concept of expanding existing city infrastructure to these immediate neighbouring districts and creating a 'mega-city' has often been suggested by city planners. A new expansion planning model for the Indian capital of Delhi is already in the pipeline and other cities like Chennai are discussing the option of expanding their infrastructures to include neighbouring regions (Srivathsan, 2011). Although the mega-city plan is inevitable, it can be argued that until marked improvements are made to major infrastructure systems (like water, sewage, roading, and solid waste management) in surrounding areas, people will continue to migrate into the existing city limits where better infrastructure exists.

Improvements to solid waste management in developing cities are generally driven to achieve two objectives. One is increasing the scope of the service to a minimum benchmark. The other is to expand coverage so that increasing populations can be serviced. The real issue is that finances are a constraint in developing cities. Most service providers do not know if their current spending levels are sufficient or not, how much more needs to be spent to increase the scope of services and how best to estimate costs for city expansions (Diaz et al., 1996).

Zhu et al (2008) provides some advice on improving the scope of services in the Indian context. Their book describes (1) the present scenario of SWM in urban areas of India, (2) the system deficiencies that exist, (3) the steps that need to be taken to correct SWM practices in compliance with the 'Municipal Solid Waste (Management and Handling) Rules 2000' -- the legal framework for solid waste management in India-- and (4) cost yardsticks to estimate costs for improved waste management services. Another publication, the recent UN-habitat book by Scheinberg et al (2010b) was a great effort to collate fresh new data for 20 cities around the globe, out of which 16 were cities from industrialising nations. Under the financial sustainability topic in the book, the authors provide expenditure and budget data of the formal service providers for each city. Collecting comparable SWM cost data from developing countries has a number of challenges, especially from regions where the informal sector forms a large proportion of the system (for more details on data issues for cost estimation in SWM, refer to Parthan et al.(2012a)). But as Wilson et al (2012) rightly points out, " If knowledge is power, then a city without knowledge of its solid waste system may lack the power to make positive changes. The quality of waste data in a city could be viewed as a proxy measure for the quality of its overall management system, of the degree of commitment of the city, or even of the city's governance system". Most developing cities need to focus upon collecting and documenting solid waste information for planning purposes. Also, because cost data are hard to collect, the data provided in Scheinberg et al's(2010b) report, along with the data collected for the research in this chapter might be useful for future cost studies.

4.1.1 Objectives

Cost questions that need addressing are stated below:

One set of questions relate to estimating costs for planning *improvements* to the existing level of service. The first two questions posed are--

What is the total expenditure required to ensure a certain benchmark level of service?

How does it compare with actual expenditures?

The third question relates to estimating costs for planning expansions for the service to include more areas of a developing city. The question posed here is-

What are the additional costs of extending coverage to handle urban migration issues discussed in Section 4.1?

4.1.2 An Indian case study: Chennai

For purposes of this study, an Indian city located in the south of India was chosen (see Figure 4.1). Chennai, the third largest city in India, a state capital and a bustling metropolis , has a total population of8.9 million spread over 1189 square kilometres (IndianCensusBureau (2011)) and well represents a typical urban city of an industrialising nation. The English language is widely spoken in Chennai along with the local language Tamil. Chennai is known for its information technology, automobile manufacturing and Tamil film industries. It is a major commercial, cultural and education hub for the south of

India. Chennai is located on a flat coastal plain and has a hot and humid climate with a maximum temperature of 38-42 degree Celsius in June and a minimum temperature of 18-20 degree Celsius in January(http://www.wikipedia.org/, acessed 27th July 2012).The annual monsoon season is between mid-September to mid-December, which is when Chennai get most of its rainfall.

The Corporation of Chennai (CoC) is the biggest service provider in Chennai city servicing a population of 4.68 million residents ; alongside the town municipalities that service the surrounding larger suburbs and the town councils called 'panchayats' operating in smaller suburbs(http://www.cmdachennai.gov.in/, acessed July 27th, 2012a). For administrative purposes CoC is divided into 10 zone units (see Figure 4.2) that is further divided into155 wards units (Esakku et al., 2007). The CoC's sample used for analysis in this chapter covers a variety of income groups with average per capita monthly incomes varying from 10 USD to 1500 USD (1USD=45 Indian rupees in 2006), ward population densities varying from 6000 persons per sqkm to 195,000 persons per sqkm, and includes a private contractor operating alongside. However, the sample excludes a number of independently operating community organisations (CBOs) because comparable data from CBOs was unavailable for this study. These independently operating community groups, known as Exnoras, collect a small fee of about 5-10 USD (1 USD=45 Indian Rupees in 2006) per family per month from the neighbourhoods that they operate in. Table 4.1provides details for the three types of service providers involved in managing solid waste in Chennai, namely the Corporation of Chennai (CoC), the private contractor employed by CoC, andExnoras, and their roles in implementing the *Municipal Solid Waste Management and Handling Rules* (MoEF, 2000) - the governing framework for improved SWM in India.

Figure 4.1. Map of India
(Axelsson and Kvarnström, 2010)

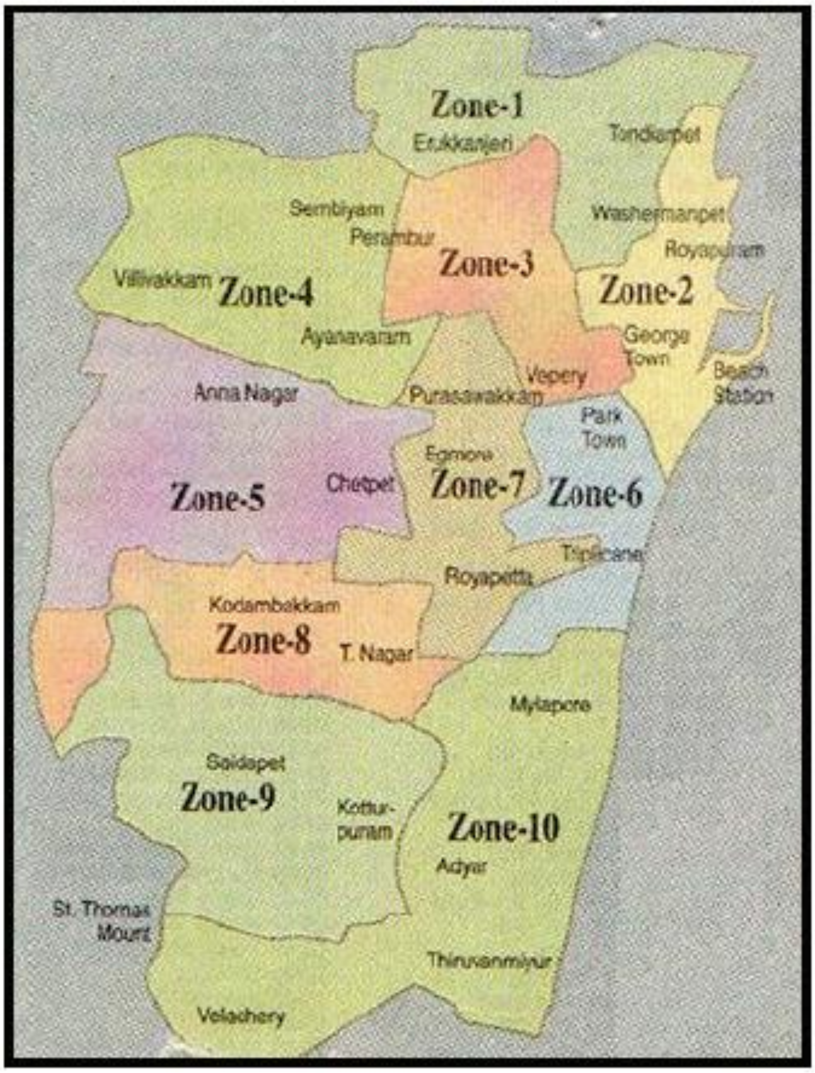

Figure 4.2. Administrative zones of Corporation of Chennai
(http://www.chennaicorporation.gov.in, acessed 27th July 2012)

Table 4.1: Summary of SWM Organisations in Chennai, India

Sources: (Anand, 1999; Axelsson and Kvarnström, 2010; Esakku et al., 2007; Srinivasan, 2006)

	Organisation	Type	Population served in millions and (Area Serviced in sqkm)	SWM Activities Undertaken	Amount of SW collected (in tonnes per day)	Cost per tonne (in USD)	Future plans of each organisation
1.	CoC	Municipality	3.05 (123.5)	Collection from community bins, Door to door collection (D-T-D), Street Sweeping, Transportation to dumpsite, Composting in 6 out 10 zones	2000-3200	33	source segregation, upgradation of dumpsite to a sanitary landfill.
2.	Onyx (upto 2007), Neel Matal Fanalca (2007-present)	Private Contractor to CoC	1.3 (50.5)	Same as above in the remaining 4 out of 10 zones	1100	25	mechanisation of service
3.	Exnora	Non-profit community based organisation	0.45	* D-T-D Collection, Street Sweeping, Composting	225	2.32	promoting household level recycling through community education programmes

*Includes either one or all activities listed

4.2 Materials and methods

The information and data for this chapter were obtained through a research-visit to Chennai. Non- structured interviews were conducted with an experienced CoC official and colleagues. The interviews were mostly aimed to be a discussion with officials to understand the SWM system operating in Chennai. No survey tool was used as it could not be presumed before reaching Chennai that officials would be willing to share information. The personal visit was extremely beneficial as officials were in fact enthusiastic about sharing their experiences and even provided available accounting data (see appendix C1 to C3). Follow-up telephonic and e-mail conversations were made to obtain further clarifications on the data that were provided. A literature search was also helpful in providing some information on the general system of solid waste management in Chennai. A flowchart was constructed by collating all the information obtained (see Figure 4.3). The data figures were conflicting at times, and are hence reported in ranges in the flowchart for some materials. When certain figures seemed unrealistic, the figures quoted by the experienced CoC officials who were interviewed or those available from the extensive results published in the ERM (1996) report were deemed as best estimates.

The objective of this section is to condense the cost data obtained from different published and unpublished sources for Chennai. Since the focus of this study was on costs and cost estimation questions, the details in this section provide a brief background on the system while describing the cost accounting system in Chennai.

4.2.1 System description and cost data accounting in Chennai

4.2.1.1 Existing system: CoC's material and cost description

Figure 4.3 is a flowchart describing the existing SWM system of CoC. The flowchart summarises both the mass flow (in tonnes per day) and the cost-incurring activities in the system.

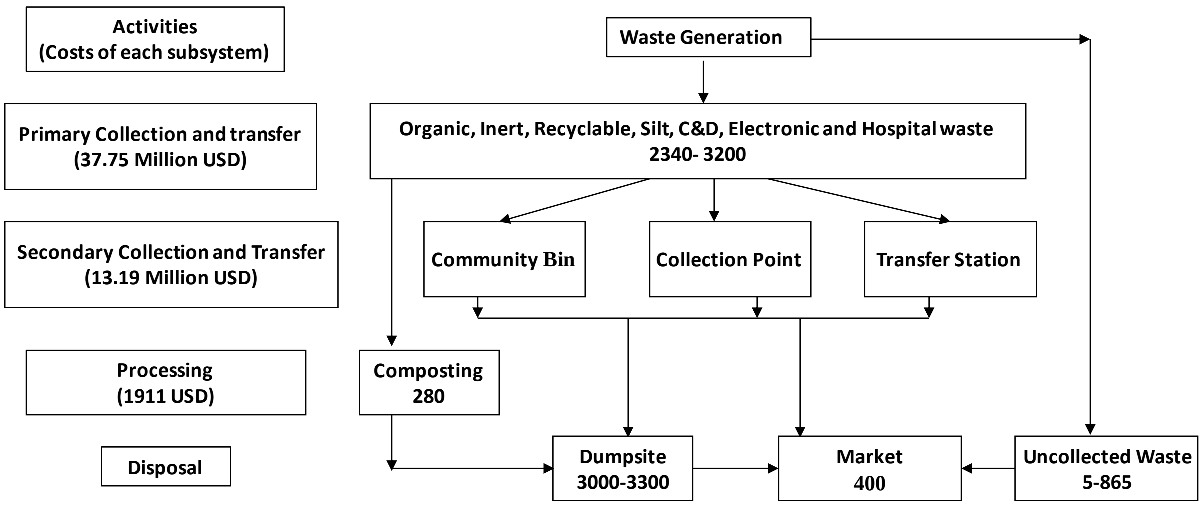

Figure 4.3: CoC's waste management system

Notes for Figure 4.3:

1.Figures reported are an approximation based on best estimates that were available from inverviews, published and unpublished sources.

2.Waste quantities at community bin, collection point and transfer stations could not be estimated as no information was available.

3.Costs of disposal at dumpsite, and revenues earned from sale of recyclables in market could not be estimated as no information was available.

SWM is the joint service of two departments of CoC. A SWM Department handles primary collection (i.e door to door collection and street sweeping) and transfer activities. A Mechanical Engineering department handles collection from secondary (i.e. temporary) storage points and transport to dumpsite. Note that all wastes collected via primary collection system go through the secondary collection and transfer stage. However, not all waste are likely to be collected via the primary and secondary systems. Wastes can also be directly deposited by residents into community bins from where the Mechanical Engineering department takes over. Except for transfer station operations, no additional costs are incurred for temporary storage in community bins and other collection points. Unfortunately no estimates were available for the quantities of wastes that are stored temporarily for secondary collection and neither were costs for transfer stations available. About 106 compost units are set up and operated by SWM department officials, whereas disposal to dumpsite from the various secondary collection points is managed by the mechanical engineering department. Additionally, there is an informal sector working outside the system that sorts for recyclables from community bins, transport vehicle pickup points and from illegal dumping corners which are accumulating uncollected waste (such as construction sites or vacant sites). The material handled by the informal sector generates revenue and ends up in a recyclables market. It is roughly estimated that 400 tonnes or more are managed by the informal sector which sells materials onto a recovered materials market. From there they are taken to a re-processing industry that converts recyclables to recycled material; no estimate of the amount of recycled material that enters back into the system was available.

4.2.1.2 CoC's cost accounting procedure

CoC's expenditures are accounted under the following two headings, each corresponding to the two CoC departments 'main activities.

1. Sweeping and Door to Door Collection (Primary Collection and Transfer) – This is the responsibility of the SWM department. The main cost drivers of street sweeping include

salaries of street sweepers, brooms, brushes, rotomould wheeled bins, wheel barrows and long brooms (Esakku et al, 2007). Collection is primarily door to door (D-T-D).Some 1300 community bins exist in the city as complete abolition of community bins is not practical, especially for collecting wastes from narrow lanes and remote locations. Costs incurred for D-T-D are that of salaries of collection staff, tricycles fitted with bells used for MSW collection from doorsteps, and bullock cart costs to collect wastes from community bins.. Processing, which mostly involves only composting, and so far being done in Zone 2 only, is the responsibility of the SWM department. As a result, composting costs are accounted as part of SWM department's expenditures. Expenditures incurred for this activity are collected from each zonal office on a yearly basis.

2. Transportation (Secondary Collection and Transport) – The Mechanical Engineering department is responsible for this activity. MSW collected from secondary storage points in each zone is mostly transported by light motor vehicles (LMVs), like a two-stroke, three-wheel motorcycle, to a transfer station located in its vicinity. From here it is transferred into heavy motor vehicles (HMVs), like dump trucks or lorries, that transport the waste to the one of the two open dumps in the city. A total of 672 vehicles is available for this activity transporting 2500 tonnes of waste on a daily basis. Vehicles are serviced, maintained and kept overnight at two depots in the city- one that caters to the north of Chennai and the other that caters to the south. Transport vehicles require frequent maintenance because they are exposed to corrosive materials and heavy loads. Major cost determinants incurred for this activity include personnel costs (drivers and technicians), vehicle repair costs and operating costs (including fuel) of HMVs that make two trips a day and of LMVs that make 4

trips a day, but exclude capital and depreciation costs of vehicles which are described below.

To fully understand the components contributing to the costs of each department, further information was sought from CoC. The cost components for the SWM and Mechanical Engineering department were found to be disaggregated into the following four categories:

- Personnel
- Operating
- Repairs and Maintenance
- Administration

Personnel charges include salaries, leave salary surrender, wages, reimbursement of medical expenses, welfare expenses, uniform, payment to casual staff, travel concession, hospitalisation benefits. A sample is provided in Appendix C3.

Operating costs include costs incurred by collection workers for small items such as brooms, medicines, masks etc. and also include costs of contracted private service providers (i.e., Onyx or Neel Metal Fanalca).

Repairs and maintenance are for vehicle repair charges and maintenance of compost bins.

Administration costs including telephone charges, electricity, office maintenance expenses, and any other day-to day miscellaneous expenses.

Table 4.2 is one such typical dataset for primary collection in the year 2007-08. Other samples of this very large dataset, in the form of yearly cost data, are provided in Tables C.1 to C.3 in the Appendix C.

Table 4.2:Example for cost breakdown (in USD)for primary collection in 2007-08

	personnel cost	operating cost	repair & maintenance	administration cost
zone 1	1,736,911	35,711	7,689	889
zone 2	2,357,467	45,133	8,422	1,467
zone 3	2,681,600	49,267	18,400	8,867
zone 4	1,918,489	43,933	22,200	55,467
zone 5	2,538,556	53,644	15,600	45,400
zone 6	354,489	2,098,689	-	3,044
zone 7	2,308,711	52,556	18,356	44,533
zone 8	484,156	4,023,111	-	6,133
zone 9	2,257,778	45,533	6,600	49,689
zone 10	572,689	2,875,467	-	822

Costs of contracts for private service providers were also accounted for under operating expenses. Zones 6, 8 and 10 were contracted to the private service provider. CoC is still responsible for certain miscellaneous expenditures in the privatised zones (such as central administration's fixed term employees' salaries and benefits), however, the overall expenditures by CoC are significantly lesser for those three zones. Because all zones were not uniformly contracted to private service providers, it was decided to exclude the privatisation expenses before using the data to estimate costs at a later stage in this study. The waste quantity data for each zone was aggregated from the weekly waste quantity summary report for the year 2007, available from the CoC website. The zone wise cost and waste data from CoC, which will be used to answer the second question posed in this study, are summarised in Table 4.3.

Table 4.3: Zone-wise expenditures and waste quantities for Chennai in 2007-2008

	Total cost for collection (in millions of USD in 2007-2008)	Privatization costs (in millions of USD)	Total costs excluding privatisation considered for analysis (in millions of USD)	Total tonnes collected in thousands in 2007-2008	TPD	cost/tonne
zone 1	1.78	0.00	1.78	83	227.98	21.41
zone 2	2.41	0.00	2.41	134	368.34	17.94
zone 3	2.76	0.00	2.76	91	250.49	30.17
zone 4	2.04	0.00	2.04	88	243.72	22.93
zone 5	2.65	0.01	2.64	196	538.35	13.47
zone 6	2.46	2.09	0.36	14	41.00	24.22
zone 7	2.42	0.00	2.42	52	143.04	46.43
zone 8	4.51	4.02	0.49	13	36.54	37.09
zone 9	2.36	0.00	2.36	88	243.25	26.58
zone10	3.45	2.87	0.58	18	51.48	30.87

Source: CoC 2007 expenditure statement

4.2.2 Yardsticks to estimate costs of SWM in India

A public-interest litigation led the Ministry of Environment and Forests (MoEF) in India to develop a set of mandatory guidelines to assist solid waste managers to improve the level of service in the country. The 'Municipal Solid Waste (Management and Handling) Rules 2000' (MoEF, 2000)lays out the benchmark level of service that SWM service providers are expected to achieve while progressively eliminating the previous system in which residents would deposit mixed waste from their households into community bins and municipal vehicles transporting this waste to dumpsites. The improved level of service includes the following seven recommendations (Asnani, 2006; Zhu et al., 2008) :

1. Prohibit littering on the streets by ensuring storage of waste at source in two bins (one for biodegradable waste and another for inerts and recyclables)
2. Door to door (D-T-D) collection of waste at pre-informed timings on a daily basis.
3. Street sweeping of all residential and commercial areas on a daily basis.
4. Replacement of open waste storage community bins with closed ones for secondary collection and storage.
5. Transportation of waste in covered vehicles on a daily basis from secondary collection points.
6. Treatment of biodegradable waste by composting.
7. Construction of engineered landfills.

Much has already been written about how service providers in Chennai are going all out to implement the improved practices as suggested by the municipal solid waste management and handling rules (Anand, 1999; Axelsson and Kvarnström, 2010; Esakku et al., 2007; Srinivasan, 2006). The benchmark level of service that Indian service providers are expected to achieve are the above seven recommendations specified by MoEF(2000). CoC currently (fully) provides three out of the seven recommendations in the ten zones that it services. They are recommendations No. 2 i.e. D-T-D collection, No. 3 i.e. street sweeping, and No. 5. i.e. transportation to dumpsite (note that wastes transported are from the existing (open) waste storage community bins only). Composting of waste has been initiated in one Zone (Zone 2) so far, but more details were unavailable.

In this section we try to answer the first question we pose, i.e. -

What is the total expenditure required to ensure a certain benchmark level of service?

Zhu et al (2008) recommends yardsticks for deployment of human resources and equipment to help solid waste managers work out costs for improving SWM according to MoeF guidelines. With the help of the yardsticks provided by Zhu et al (2008), cost equations requiring mostly population estimates were developed. Costs were predicted using the cost equations and ward population data for a selected year, in 2006, as factor prices of individual items were available only for that year. Input prices are taken from Zhu et al (2008) except where stated. A spreadsheet was developed (see Table C.4 in Appendix C) to calculate predicted costs for the services that are currently provided by CoC, i.e., D-T-D collection, street sweeping and transportation to dumpsite. These predicted costs were compared with actual expenditures of CoC in 2006 in the next section.

Note that only labour and operating and maintenance (O&M) costs are estimated in this study. Capital costs were not estimated because of the uncertainty over the true costs and the lifetimes of CoC's assets. This is complicated because of the many sources of capital for equipment (NGOs, national/state government).Also note that labour and, O&M costs provided and estimated below are in thousands of Indian rupees, abbreviated as kRs. (45 Indian rupees= 1USD in 2006), per year per zone.

The yardsticks used, along with assumptions made to develop activity-wise cost equations, are listed below. The cost equations are useful to arrive at the predicted costs for the three upgraded level of services that CoC is already providing, which can then be used to determine if expenditures for the existing scope of services are sufficient or not.

4.2.2.1 D-T-D collection

Assumptions:

1. The projected urban population of each ward is calculated for the year 2006 based on 2001 census population data from wards with a growth rate of 3.95%[1] per year.
2. A yardstick of 1 containerised tricycle/wheel barrows per 1000 persons is used.
3. 1 sanitary worker assigned per containerised tricycle / wheel barrows. In cases where female workers are involved in primary collection, they may be given containerized handcarts. Hence the total requirement for equipment for D-T-D collection is split into 2- equal numbers of tricycles and wheelbarrows.
4. 1 part time supervisor per 25 sanitary workers.
5. TOTPOP= total population of ward in 2006
6. O&M cost of Rs 1500/year/collection vehicle (barrow or cycle)
7. Price of labour in 2006 =Rs 6000/month for full time and Rs. 4500/month for part-time supervisor.

Labour Cost (kRs/year/zone) = ((TOTPOP/1000)*6000*12) + ((TOTPOP/1000)/25)*4500*12)

O&M cost (kRs/year/zone) = 1500* (TOTPOP/1000)

[1]The 3.95% is Chennai's growth rate as per 2001 census. It is assumed that the ward population growth would be constant from 2001-2006 and that all wards would experience a uniform increase.

4.2.2.2 Street Sweeping

Assumptions

1. One sanitary worker (price of labour in 2006 =Rs 6000/month) per 250 m of road length in high density area, and 1 worker per 400m in medium density area.
2. Bus route roads were classified as high density roads whereas interior roads were categorised as medium density. No areas were classified as low density for street sweeping as Chennai is a high population density metropolitan city.
3. Road lengths were divided equally between wards, as only zonewise road lengths in kms were available.
4. Each street sweeper is provided with a wheelbarrow or tricycle with fitted containers. 2006 prices for labour= Rs 6000/month, O&M costs for containers placed inside handcart/wheelbarrow = Rs 1500/year
5. BUSRD= Bus route road length in kms, TOTWRD= total number of wards, INTRD= length in kms of interior wards

Labour Cost (kRs/year/zone)= [(BUSRD/TOTWRD)*1000)/250) + ((INTRD/TOTWRD)*1000)/400)] * 6000*12

O&M cost (kRs/year/zone) =[(BUSRD/TOTWRD)*1000)/250) + ((INTRD/TOTWRD)*1000)/400)]* 1500

4.2.2.3 Transportation

Assumptions

1. Trucks with container lifting device used in wards having population more than 50,000.
2. Tractors with container lifting device used in wards having population less than 50,000

   A yardstick of 1 vehicle per 10 containers is considered.
3. In addition 25-30% standby vehicles are needed for reliability of service when existing vehicles are taken for maintenance or have a breakdown.
4. Since a mechanised system is used for lifting containers, one driver and one sanitary worker per vehicle are considered adequate. Labour costs= Rs 6000/month. No supervisors needed for this system[2]

Labour cost (kRs/year/zone) = ((TOTPOP/5000)/10) * 2*6000*12

O&M cost (kRs/year/zone)= Fuel + repairs and maintenance = 0[3] (no advice provided in Zhu et al, 2008)

4.2.3 Future development scenarios for Chennai

What are the additional costs of extending coverage to handle urban migration issues? This was the second question we posed in this study.

[2] Transport vehicles are suggested to be centrally monitored (Zhu et al, 2008).
[3] This is suspected to be relatively low compared to other costs.

Two types of data for a single time period are needed to answer the second question: data on total costs or expenditures, and waste quantity data. Although such data for the 155 wards would have been ideal, the fact that the ten zones comprise a broad range of populations, sizes, per-capita incomes and demographics was deemed as a good compromise to smaller sample size available for a cost function analysis.

4.2.3.1 Scenario analysis

In developing cities, better infrastructure and lifestyles drives populations into already overcrowded parts of the city. In Chennai, this was the trend until some years ago when it was realised that areas outside the present city limit area of 1189 square kilometers are growing fast and that they have not been sufficiently integrated into the metropolitan areas or the CoC limits. The recently released 2011 census data confirms that the population growth has slowed down within the CoC, while some of the adjacent districts surrounding the CoC limits has substantially increased. These adjacent districts are 16 municipalities, 20 town panchayats and 10 village panchayat unions. For example, between 1991 and 2001, CoC witnessed a decadal growth of 13 percent, but between 2001 and 2011 it dropped to 6 percent. During the later period, population growths in the adjacent districts increased from19 to 39 percent. As a result, plans to develop a mega-city are currently under way for Chennai. This means that the existing infrastructure such as transport and even solid waste management could be extended to these potential residential nodes surrounding the present city limits. Despite these figures, it is arguable that until significant changes to non-urban infrastructure are made, the historical trend of populations migrating into the city will continue. Figure 4.4 shows the expansion plans for Chennai in the coming years. The blue lines indicate the potential residential nodes surrounding the CoC limits and the purple lines are the overall boundaries of the Chennai city.

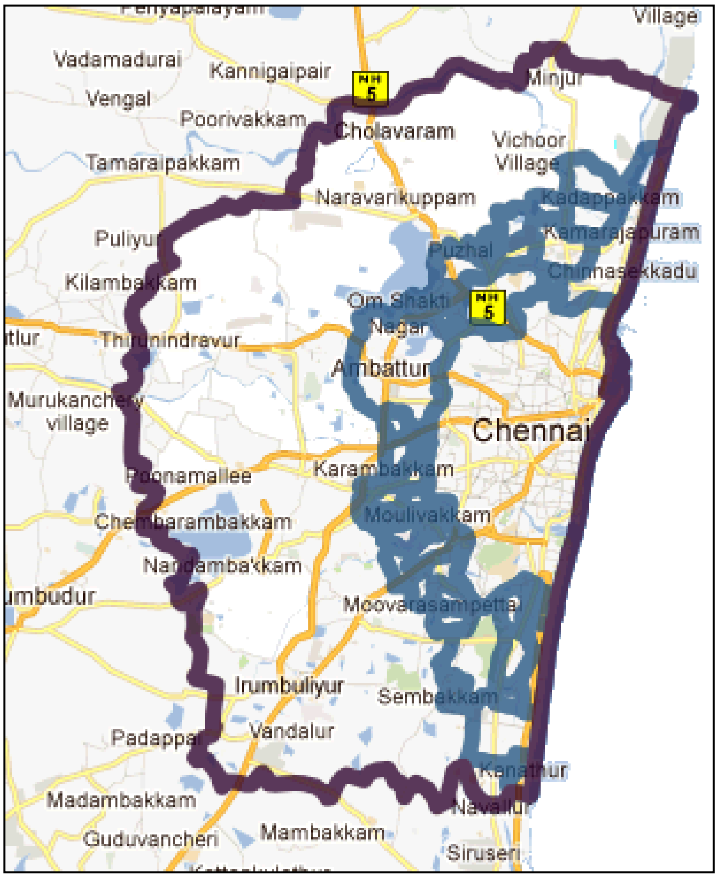

Figure 4.4: Chennai city boundaries
(http://www.transparentchennai.com/, accessed July 27th, 2012)

With the above background, it was decided to estimate future costs for two scenarios. Scenario 1 is defined as the 'growth within city' scenario. In this future, waste quantities are estimated for populations that migrate into Chennai city at the given rate per zone as shown in Table 4.4.

Table 4.4: Data on population growth and per capita waste generation in CoC zones

Corporation Zones	Population in 2007 (in millions)	Annual population growth rate (%)	Kg/person/day (assumed to be constant in CoC zones)
zone 1	0.52	1.00	0.585
zone 2	0.47	1.40	0.585
zone 3	0.58	0.64	0.585
zone 4	0.63	1.89	0.585
zone 5	0.68	0.93	0.585
zone 6	0.43	0.65	0.585
zone 8	0.59	0.61	0.585
zone 9	0.52	2.23	0.585
zone 10	0.62	2.13	0.585

Data sources:
1. Zone-wise 2007 expenditure statement provided by CoC
2. (http://www.cmdachennai.gov.in/, acessed July 27th, 2012b)
3. ERM(1996)

Under Scenario 2, or the 'expansion of city bounds' scenario,CoC expands its current operations to 14 Municipalities, 20 Town Panchayats and 21 Village Panchayats around Chennai City, having populations and per-capita generation rates as shown in Table 4.5 below.

Table 4.5: Data on population growth and waste quantities in future potential residential nodes

	Population in 2001	Annual population growth rate	kg/person/day
Municipalities	1580500	4.02	0.585
Town Panchayats	385720	4.38	0.439
Panchayat Unions	730792	4.37	0.293

Data sources:
1. Zone-wise 2007 expenditure statement provided by CoC
2. (http://www.cmdachennai.gov.in/, acessed July 27th, 2012b)
3. ERM (1996)

4.3 Results and Discussion

4.3.1 Is Chennai spending enough?

Table 4.6 shows that with respect to existing operations, the 25 million USD that Chennai spent on SWM in 2006 is quite close to the costs predicted using yardsticks provided by Zhu et al. O&M costs of transport vehicles could not be accurately predicted (assumed to be 0 here), which is a limitation, and could have possibly given a clearer picture.

Table 4.6: Comparison of predicted and actual costs for SWM activities in Chennai

(Costs in millions of 2006 USD; 1 USD= 45 Indian Rupees in 2006. Note that predicted costs are available for wards for the year 2006-07, whereas zone wise actual costs are available for 2007-2008. Only total costs were available for a fair comparison.)

SWM Activities	(c) Labour Predicted (Actual)	(d) O&M Predicted (Actual)	Total (c + d) Predicted (Actual)
(a) Door to door collection (b) Street sweeping	(a)8.688 + (b)11.884 (16.489)*	(a)0.176 + (b)0.005 (0.291)*	20.753 (16.780)
Transportation**	0.346 (3.389)	0 (4.742)	0.346 (8.131)
Comparison of total O&M system costs Predicted Costs = USD 21.099 million Actual Costs = USD 24.911 million			

* actual costs from CoC records were inclusive of both D-T-D and street sweeping costs
**from community bins, secondary collection points and transfer stations

Based on the estimates in Table 4.6, for primary collection, i.e., D-T-D collection and street sweeping, labour should cost 20.572 million which is 25% higher than the actual costs incurred by corporation of Chennai. The difference can be only partly explained by the fact that the number of collection workers employed by CoC and private contractor is 12400, 511 workers less than the predicted 12911. The difference could also be a reflection of the fact that the actual D-T-D collection and street sweeping is not 100% while the prediction assumes that there is 100% primary collection of waste.

When predicted and actual transportation costs were compared it was observed that actual labour costs for transporting waste from secondary collection points to the dumpsite were significantly higher than predicted costs. Transportation of waste has been traditionally carried out by a whole other department in CoC. As discussed in the previous section, the mechanical engineering department of CoC employs a separate labour force to carry out its operations. Recall that the number of transport vehicles available for this activity is 672 whereas using the yardsticks prescribed by Zhu et al a total of 108 transport vehicles should be sufficient, operated by 216 drivers and accompanying workers; this shows the value of using yardsticks. However, the difference could also be due to the fact that there might be other additional costs contributing to actual labour costs of transportation for CoC (such as maintenance workers, part-time drivers and so on) that Zhu does not take into consideration. Transport vehicles in developing countries need constant repair and maintenance due to the characteristics of the mixed waste they carry (Zhu et al., 2008). It is hence not surprising that the costs of repair and maintenance for this activity are substantial. Unfortunately it was not possible to predict the O&M costs of transportation as there was insufficient advice provided by Zhu et al(2008). This was probably because there are a number of variables such as fuel costs, age and make of transport vehicle used , distance between secondary collection site and dumpsite and so on, that make estimating the O&M costs for this activity very challenging.

Holding the population constant, if the scope of services had increased (or were on par) to the standard recommended by MoEF(2000) in 2006, it is estimated that the predicted costs would rise by about 2 million USD. An additional half a million USD would have been required for the existing two dumpsites in Chennai to be upgraded to a sanitary landfill. Composting costs, were also not included in the comparative analysis; based on the yardsticks the annual operating cost would rise by 0.601 million USD for composting. Another significant cost-incurring activity that has not been studied in detail due to insufficient data are operations involved in transfer stations. There are currently 8 transfer stations in Chennai. Although actual operating costs from these stations were not available, the predicted costs for eight transfer stations were calculated using the prescribed yardsticks, which resulted in a total operating cost of 0.408 million. Finally, although no additional operating costs would have been involved in transporting wastes from the upgraded (closed container) community bins recommended by MoEF, it is estimated that replacing the open bins with closed bins would have incurred 0.549 million in 2006 prices.

4.3.2 Where other developing cities are at?

How does Chennai fare in comparison with other developing cities in the world? In reality this question is complicated to answer. It is a well-known fact that cost data on SWM come in a wide variety of forms and a fair comparison is almost impossible. Cost data and accounting issues have been discussed in detail in Parthan et al (Parthan et al., 2012a) and the reader is referred to that paper for a more detailed understanding of the effects of data issues on cost comparisons for waste management. The most recent 20 cities dataset published in the UN-habitat book is undoubtedly a great effort to compile comparable data. Even that data is not without its imperfections (Wilson et al., 2012), but it was decided to take advantage of the fresh cost data available for a quick comparison with our benchmark city, Chennai. The expenditures per person for ten developing cities from the UN-Habitat dataset are provided in Table 4.7. The reason for reporting cost per person instead of the more common benchmark indicator cost per tonne was that most costs and population data were available for a single year, in 2008. Also population estimates are generally more reliable than waste quantity estimates, especially in developing countries (Parthan et al., 2012b; Parthan et al., 2012a)

Table 4.7 shows the Brazilian city of Belo Horizonte has the highest per capita costs. Application of more advanced technologies for waste management in the city as compared to the others in this dataset is probably the reasons for the high costs. Separate kerbside collection of recyclables, about 89% waste of waste generated being disposed in a sanitary landfill, and integration of the informal waste pickers into the formal system are some of the special features of Belo Horizonte's SWM system (Scheinberg et al., 2010b). In contrast, the town of Ghorahi in Nepal has the least cost per capita. Weak municipal finances is probably the reasons for the low per capita costs; revenues and hence budgets are low, no user fee is charged currently and collection coverage is at a low 46%.

In the absence of detailed cost data and varying characteristics of developing cities, the only option was to analyse costs from a broader perspective. In the case of solid waste management, the question that comes to mind is how much of waste that is generated is managed (this was crudely termed as 'SWM efficiency') and what does it cost (in terms of per capita expenditure) to manage it? The results are recorded for the different developing cities in Table 4.7.

Readers are asked to note that only costs and wastes managed by the formal sector are reported here. A closer comparison would need more details such as cost components, activities included, informal sector costs and incomes earned, which unfortunately are more challenging to account for when multiple organisations are operating alongside the municipality in a city.

Additionally, varying sizes of cities and different GDP's per capita per city also make comparisons between countries difficult and unfortunately no further analysis could be undertaken between these different cities. But nevertheless the data computed in Table 4.7 might be of interest to some readers.

Table 4.7: Expenditures and waste management efficiencies for different developing cities

Country	City	per capita cost per year	tonnes/day handled by formal sector	tonnes/ day generated	SWM efficiency (waste handled/waste generated*100)
Tunesia	Sousse	14.59	176	187	94
Philippines	Quezon City	2.75	1356	2017	67
Nicaragua	Managua	12.43	1028	1153	89
Nepal	Ghorahi	0.73	6	9	69
Bangladesh	Dhaka	2.25	2789	3200	87
India	Delhi	7.20	4595	6979	66
Republic of Mauritius	Curepipe	13.83	65	65	100
Peru	Canete	2.39	24	33	72
India	Bengaluru	5.42	4554	5750	79
Brazil	Belo Horizonte	47.09	3525	3552	99
India	Chennai	10.12	3636	3731	97

4.3.3 Spending levels of other million-plus Indian cities

The Indian cities did seem more comparable and so it was thus decided to focus on the two Indian cities from the UN-habitat dataset, namely Delhi and Bangalore, and compare with our benchmarked city of Chennai. Chennai municipality's waste management efficiency was computed as 97% whereas Bangalore's was 79% and Delhi's was 66%. In both Chennai and Bangalore, a majority of the population is serviced by the municipality, which plays a major role in managing waste from collection through disposal, whereas Delhi's waste collection depends largely on the informal workers that transfer waste from households to community bins for a monthly fee. This may have an effect on the per capita cost variation betweencities which otherwise have uniform labour rates for formal municipal workers.In fact, the high % for Chennai makes it an excellent choice for cost analysis. Trying to do a similar analysis for Delhi would be so much more difficult because so much more waste is in the informal sector. Next, assuming that only spending levels determine waste management efficiencies, the additional costs that Delhi and Bangalore needed to spend in 2008 to achieve Chennai's efficiency rates were calculated and summarised in Table 4.8.

Table 4.8: Predicted costs for other Indian cities in 2008

Indian cities	What it **should** cost (in 2008)	**Actual** costs (in 2008)	Additional costs needed to match Chennai's benchmark in 2008
Delhi	140,167,131 USD	99,726,833 USD	2.92 USD/person-year
Bangalore	78,936,000 USD	42,295,420 USD	4.70 USD/ person-year

In summary, the above results are an attempt to examine expenditures and level of service for solid waste management in developing cities with a view to determine the expenditure required to ensure a certain benchmark level of service. The benchmark in the case of Indian cities was the framework provided by the Municipal waste management and handling rules (MoEF, 2000) and yardsticks based on good practice from Indian cities were used to seek guidance to estimate costs. These costs, although difficult to compare with cities outside India, provide the readers with a rough idea of where other developing cities around the world are at, but are definitely useful for comparing costs with other million-plus Indian cities. The above analyses were aimed at answering the first question we posed

"What is the total expenditure required to ensure a certain benchmark level of service? And how does it compare with actual expenditures?"

4.3.4 Estimated quantities and costs

The second objective of this study was to estimate additional costs for two future scenarios for Chennai. Scenario 1 is the 'growth within city' scenario, i.e populations continue to migrate into the present city limits, and the second is 'expansion of city bounds ’or scenario 2.

A 'cost curve' relates the per ton cost of an activity or path to the scale of that activity or path. In general, the greater the volume of units processed, the lower the per unit cost because fixed costs can be spread over more units and more efficient technology can be applied. This effect is referred to as 'economies of scale'. The cost curve using waste management data in Table 4.3 from the ten zones in Chennai city is presented in Figure 4.5. The cost equation CPT=32.732-03035*TPD (36<TPD<540), where CPT is cost per tonne (in 2007 USD dollars) and TPD is the waste quantity collected per day; this can be used to predict future costs for Chennai.

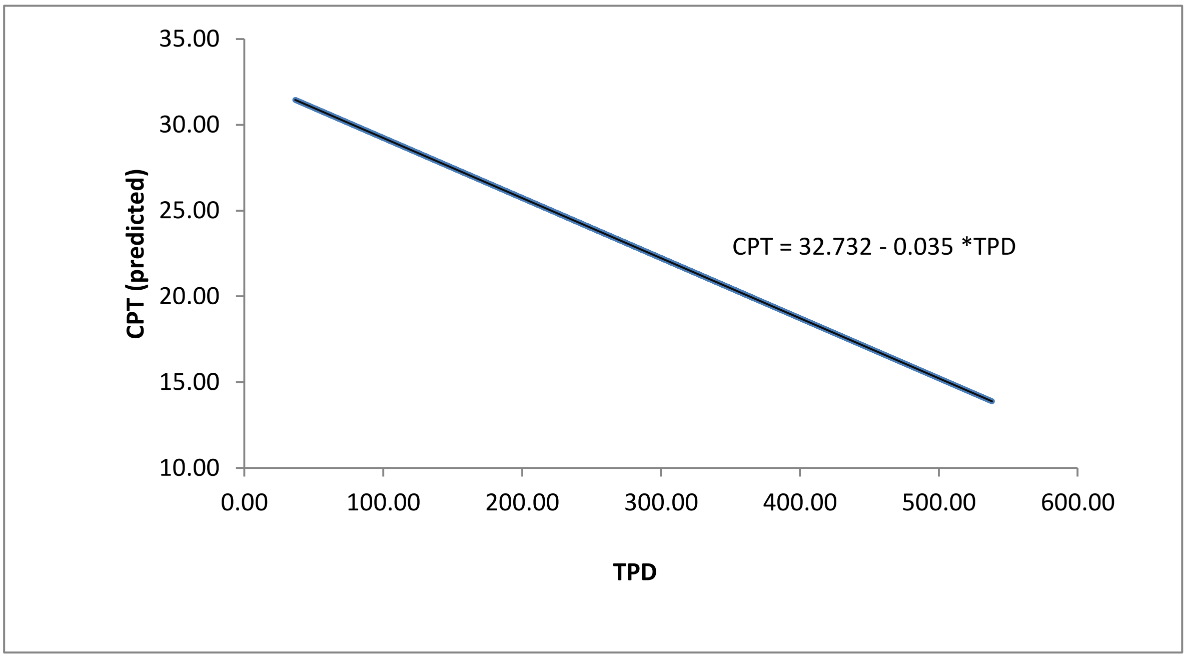

Figure 4.5. Estimated costs for solid waste management by CoC;
(Note that this relation is valid only over the range 36 < TPD < 540)

To estimate CPT for the two future scenarios, firstly waste quantities needed to be estimated. The waste quantities for each scenario were estimated using annual growth rates and per capita waste generation rates from Tables 4.4 and 4.5 in section 4.2.3.1. The estimated waste quantities and corresponding costs using the cost curve are in Table 4.9.

Table 4.9: Estimated quantities and costs for each scenario

Corporation Zones	Scenario 1		Scenario 2	
	TPD	CPT	TPD	CPT
zone 1	305.89	22.025	379.58	19.45
zone 2	281.17	22.891	519.94	14.53
zone 3	341.36	20.784	402.09	18.66
zone 4	373.59	19.656	395.32	18.90
zone 5	403.86	18.596	689.95	8.58
zone 6	253.92	23.844	192.60	25.99
zone 8	346.33	20.610	188.14	26.15
zone 9	313.39	21.763	394.85	18.91
zone 10	367.65	19.864	203.08	25.62

The average total costs of serving a population of 5.04 million by managing 2001.14 tonnes of waste is 25 USD/tonne for CoC.

Scenario 1:

Assuming that populations migrate into Chennai city at the given rate per zone (refer Table 4.4), the additional waste that will need to be managed in this scenario is equal to 986.013 TPD. Suppose that this waste increase is equal in each zone. The marginal cost of managing the additional 98.6th tonne per zone is estimated at 3.45 USD/tonne whereas the average total cost would be29.28 USD/tonne.

Scenario 2:

If CoC is required to extend its operations to the 14 municipalities, 20 town panchayats and 21 village panchayats, the additional waste that will need to be managed is 1516.047 TPD. Again, in the absence of better data, assuming that the waste increase is equal in each of the 10 zones of Chennai,the marginal cost of managing the average 151.60th tonne per zone is estimated to 5.31 USD/tonne, whereas the average total cost would be 27.42 USD/tonne.

A note here that dividing the predicted quantities equally between 10 zones is probably unrealistic. If similar ward-level data for the 155 wards were available, a broader range of quantities could be predicted. With regards to scenario analysis, as previously described in section 4.1, the likelihood and implications of the two hypothetical scenarios researched in this chapter depend on whether future populations will continue to migrate to CoC serviced areas of Chennai where better infrastructure exists, or whether the mega-city expansion plan will actually materialise for Chennai in the coming years. However, more importantly, the objective of this sub-section is to estimate marginal costs (i.e. the change in the totalcost resulting from unit change in service) when planning SWM expansions for both cases. Note that it is assumed here that all other factors stay constant, such capital, labour and input prices, and the only variation is the additional waste managed by CoC in each scenario, which then causes the changes in the cost.

Generally the most common approach adopted is to analyse the two future scenarios based on average costs. For example, from Table 4.10, at first glance one might say that based on average costs, with the given capacity, the cost of managing waste when CoC expands its current operations to surrounding areas is more cost-effective than handling additional waste due to populations that migrate into existing CoC limits. This is because the average cost of the later is less than the average cost of the former, i.e., scenario 1.

The right way to analyse future development scenarios would be to look into marginal costs- the cost of managing the additional waste in each scenario. And not the average costs which is the total cost divided by total waste, or the other commonly used approach of simply using the previous year's expenditure, known as recurrent costs. As it assumed here that over a period of one year all other factors are constant, the coefficient of the independent variable (which is the quantity of additional waste) is what contributes to the additional or marginal cost. In scenario one, the marginal cost was estimated to be 3.45 USD/tonne whereas in scenario 2 it was 5.31 USD/tonne. Using those figures and with the given capacity of CoC, the additional cost required in that year for all ten zones would be 40, 820 USD for scenario 1 and 96,600 USD for scenario 2 (see Table 4.10). Note from the table how finances could easily be overestimated if average costs or recurrent costs are used instead.

Table 4.10: Comparison of traditional estimation methods and marginal cost estimation for Chennai's development scenarioanalysis

	Scenario 1	Scenario 2
Additional waste per zone (in tonnes per year)	1183.2	1819.2
2007 recurrent costs	24,420,000	24,420,000
Average cost (in 2006 USD/tonne)	29.28	27.42
Marginal cost (in 2006 USD/tonne)	3.45	5.31
Estimated additional annual costs (in USD), using average costs	346,440	498,825
Estimated additional annual costs (in USD), using marginal costs	40,820	96,600

4.3.5 Recommendations for future cost estimation studies

One purpose of this analysis is to point to future cost analyses needed to improve the ability to estimate costs in the complex situations found in developing countries. Two common needs for better cost estimation relate to informal recycling and household source reduction programmes. SWM when done by community, resident welfare or non-governmental organisations can be a very labour-intensive undertaking, with relatively small capital outlay. Given the lower wages in such 'non-formal' organisations, and the more labour intensive processes (i.e. with fewer and simpler vehicles staffed with more workers), at what population levels are economies of scale likely to be exhausted? Such results would be useful in contemplating the cost implications for expansion of informal recycling. The expected change in costs with the expected gain in environmental quality due to reduction in waste disposal or increase in recycling could be studied. For example, consider the upgraded system that Chennai is planning to achieve as per the MSW management and handling rules in Figure 4.6. CoC collects and disposes an average of 3000TPD of waste (Figure 4.3) and about 400 TPD of waste ends up being informally recycled. By recycling one additional tonne of waste that would otherwise been disposed in the dumpsite, how much would be saved in collection costs for CoC? How much would it cost to improve recycling practices for the CBO or RWO and how much of this extra cost to remove recyclables from the mixed waste is reduced by revenues gained from selling the recyclables? Efforts to collect specific data on recycling practices would be useful in estimating a recycling cost curve similar to that in Figure 4.5 . To start with, recycling cost data for such an analysis could include the direct and indirect costs and payments made by formal service providers to CBO's, NGOs and RWO's that employ scavengers/ragpickers to collect waste from households, while the waste quantity data should include approximate tonnes of income-generating materials or recyclables (papers, plastic, metals and so on). Cost analyses using such data from the hundred plus registered Exnoras (or CBOs operating in Chennai) would be extremely useful to show policymakers the cost benefits of encouraging informal recycling in Chennai, along with social consequences.

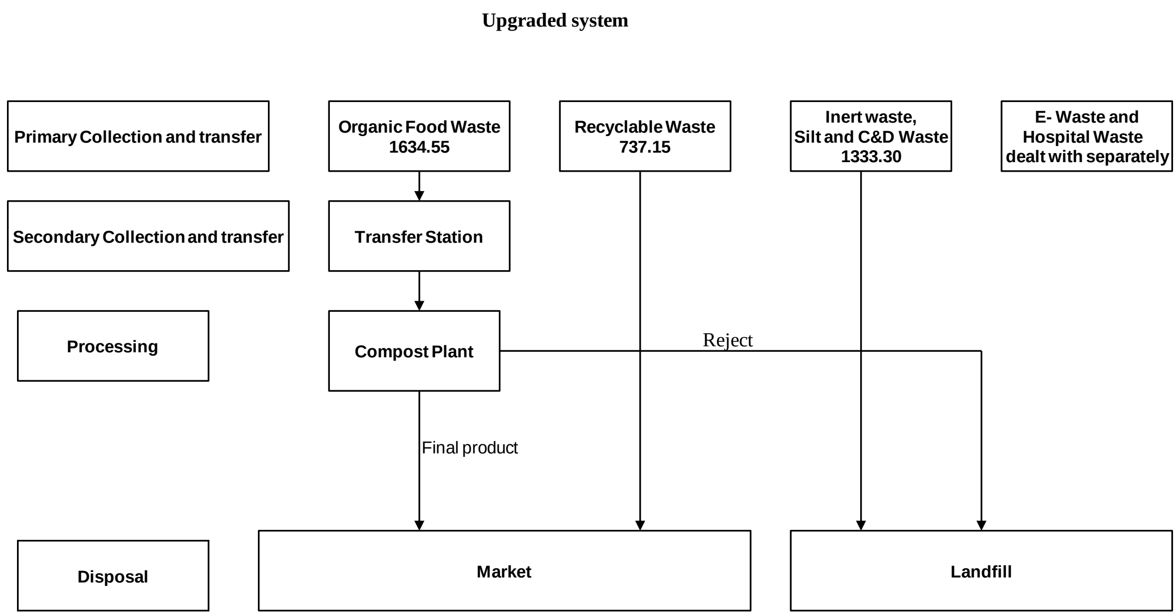

Figure 4.6: Improved system of SWM as per Indian MoEF guidelines

Lately household source reduction and segregation (separation of waste into inorganics and recyclables) practices have been a hot topic of discussion in Chennai (add references). Source separation of organics will likely greatly decrease the cost of composting. The current benchmark costs assume high quality organics coming from a good source separation process, and without these, the cost of implementing composting in India would be much higher.

4.4 Conclusions

This study attempts to highlight the importance of focusing on cost related questions for planning improvements in SWM in an urban developing city like Chennai Yardsticks provided by Zhu et al (2008) were beneficial in determining if existing resources such as labour and equipment were more or less than required. This in turn was useful in predicting costs for the existing scope of services and comparing with actual expenditures. The yardsticks can also be used to predict costs for other large metropolitan municipalities in India, as municipal labour and operating costs will be the same across cities. A major drawback was that there was insufficient advice for capital cost estimation. This was compounded by lack of data for the available capital from Chennai. Including lifetimes for capital equipment, knowledge of depreciation rates etc. are important in order to work out a total cost figure that decision-makers would normally be interested in.

Estimating marginal costs seems to be the answer when planning to extend the service to increasing populations. With constrained finances and low user-fee rates in developing cities, every additional tonne of waste that needs to be managed imposes an extra financial burden on the service provider. Estimating the link between scale of the service, and average and marginal costs help in making sure that restricted finances are spent wisely and user-fee rates are set appropriately.The future development scenario analysis conducted in this chapter can be applied to other Indian metropolitan cities that are similarly divided into administrative zones like Chennai.

The informal sector has proven to be valuable in reducing waste quantities reaching the dumpsite at little or no cost to formal service providers. Not including the effects of informal sector involvement while benchmarking costs and planning for the future development scenarios is a major limitation in this study. It is hoped that the results and method presented here can help future researchers to collect similar data from large cities in developing countries to estimate costs of informal recycling and household source reduction expansion programmes.

Other local economic factors such as prices for labour, capital, fuel and tipping fees and specific characteristics of the service such as frequency of collection, transfer station operations amongst others that affect cost have not be included in this study. Data on economic and other characteristics of the service affecting costs could be the next step in a similar study.

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CHAPTER 5: RESEARCH DIRECTIONS FOR SOLID WASTE MANAGEMENT COST FUNCTION ANALYSIS IN DEVELOPING COUNTRIES: LESSONS FROM THE HEALTHCARE SECTOR

Abstract

Significant progress has been made over the past 40 years on cost function estimation and analysis in healthcare management. From mere curve fitting exercises used to forecast costs, research advanced to study (1) factors affecting costs and increase in costs, (2) cost recovery schemes such as healthcare insurance to improve financing for the service and (3) robust techniques to model advanced healthcare systems. Both healthcare management and solid waste management are offered by multiple service providers in developing cities, both are multi-product systems, and developing country problems are almost identical in both types of services. The difference, however, is that while healthcare researchers seem to have fully understood that better alternatives to traditional cost estimation methods are vital for better planning of the service, the same cannot be said for solid waste management. Research directions for developing country cost function analyses are suggested here. One line of research could be to study the optimum municipal size (jurisdiction) and number of activities for solid waste management services for existing and future development scenarios; such studies could include determining scale and scope economies, and estimating marginal costs. Another line of research could focus on studying and controlling for factors that affect costs; effect of variables such as factor prices, ownership types, informal recycling involvement can be studied. As research advances, and better quality cost data become available, the focus could shift to improving econometric

techniques to refine the quality of the cost function developed. To start with, the methodology for estimating cost functions for developing countries can be directly borrowed from early cost function studies conducted in the healthcare sector. In the light of existing cost data issues from developing countries, the types of analyses that can be conducted with available data are also indicated.

5.1 Introduction

Driven by concerns over the increasing costs of healthcare, special attention has been directed in the past four decades towards better understanding the cost structure, cost drivers and cost behaviour of healthcare management (Eldenburg and Krishnan, 2006). The issue of costs became an important topic of research for developed nations like the United States as expenditures on the service was growing rapidly (Lave and Lave, 1984), and soon developing nations also focussed on costs in healthcare research, as the issues facing policymakers were similar even there (Wagstaff and Barnum, 1992).

Since the late sixties, there has been a torrent of research publications on the topic of estimation and interpretation of healthcare or hospital cost functions as a means to study costs of healthcare. For example, Ellis (1991) estimates that in just five years at least 3500 books and articles have been published on the subject. Cost function analyses are based on the underlying theory that costs are related to the scale of outputs. Cost function research in the healthcare sector progressed gradually over the past 40 years (see Figure 5.1). From crude beginnings, in the 1970s, that were mere curve-fitting exercises to forecast costs, more elaborate cost estimation techniques and analyses started to emerge (Lave and Lave, 1984). The 1980s research progressed to cost containment measures, such as understanding the factors contributing to differences in costs of healthcare. In the 1990s, researchers not only focussed upon factors affecting costs, they also started looking into factors affecting *increase* in costs over time, as cost recovery measures through health insurance schemes became popular. The 21st century research seems to be focusing upon using more sophisticated econometric techniques that are useful in developing a complete model of the healthcare system while also attempting to control cost increases.

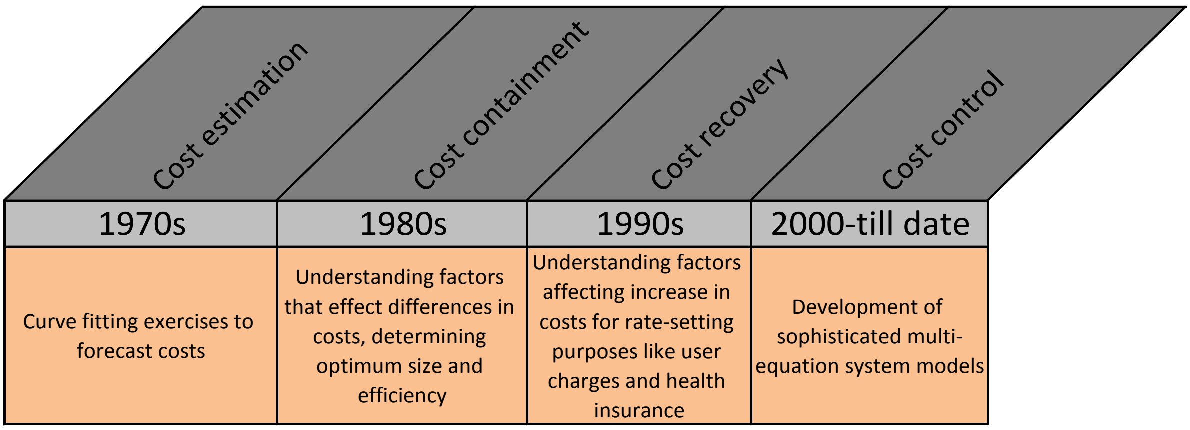

Figure 5.1: Healthcare management cost function research advancement timeline

Developing cost functions for planning is, in fact, not completely new to solid waste researchers. Economists such as Bel ((Bel and Fageda, 2010; Bel et al., 2010; Bel and Mur, 2009; Bel and Warner, 2008)), Kinnaman(Kinnaman and Fullerton, 2001; Kinnaman, 2005), Stevens (Edwards and Stevens, 1978; Stevens, 1978), Clark (Clark et al., 1971; Clark and Lee Jr, 1976; Clark and Stevie, 1981), and Hirsh (Hirsch, 1965; Hirsch, 1995) have made significant contributions to this particular field of research in developed countries. For more details from some of the above references, please refer to Chapter 2 or Parthan et al (Parthan et al., 2012a; Parthan et al., 2012b). But with the exception of the author's own works, similar studies were not found in existing literature for waste management planning in developing countries where problems of waste are more critical, expenditures are increasing significantly, but finances available for improving the service are constrained. The cost function success story from healthcare can be seen as huge motivation for waste researchers to further contribute to the limited existing knowledge relating to similar cost analyses for solid waste management, especially in developing countries.

The objective of this chapter is to firstly provide evidence that valuable lessons can be learnt on the topic of cost function analysis from the healthcare management sector ; rather than comparing solid waste cost estimation methods with those used for sewer or drinking water costs (which would at first seem logical), we would be better to compare to healthcare costs. The following section will help set the base for future research directions for solid waste researchers on this topic. Next, readers will be directed to a specific set of research questions that <u>early</u> healthcare researchers had tried to answer. There is a reason for not connecting with the more recent cost function research from healthcare. With reference to the challenges of finding SWM cost data from developing countries needed for a cost function analysis, the present level of data that is available to estimate SWM cost functions best compares to what healthcare researchers used to work with at early stages of their research. As research progressed in healthcare, the quality and accessibility of cost data also improved. Although it is hoped that the same will happen for SWM too, the type of analyses that can be done with the current level of data from developing countries is briefly summarised in section 5.3. Finally, certain recommendations are suggested for progressive advancement of SWM cost function analyses for developing countries.

5.2 Materials and methods

5.2.1 Comparison of healthcare/hospital management and solid waste management

In the past, cost functions have been developed for various kinds of public services such as transport, education, and water supply. But the finer characteristics relating to healthcare management costs and solid waste management costs are found to be strikingly similar (refer Table 5.1)when compared to other sectors. In addition, the number of publications on the topic of cost function analysis for the healthcare sector exceeds those published for other sectors. As a result, it was decided to further elaborate upon the similarities between healthcare and SWM listed in Table 5.1, instead of trying to do the same with other sectors. The similarities in the characteristics of healthcare or hospital management and solid waste management have also been pointed out by Cossu(2011b).

Table 5.1: Comparison between characteristics of healthcare management, solid waste management and other sectors

Examples	Healthcare Management	Solid Waste Management	Other sectors		
			Transport	Education	Water supply
Organisational Structure	Public, private and community hospitals	Municipal, Private contractor, NGO/CBO/RWO*	Public and private transport	Public, private and community schools	Municipal and Private (either owner operated through dug wells, boreholes, rainwater harvesting or tanker-truck operators/contractors)
Difficulty in definition of output	Number of patients treated not proportional to community health	Number of tonnes collected not proportional to achieving the goals of integrated SWM	More well defined (for ex. vehicle-miles, passenger-boardings)	Measure of educational service defined through test scores, or drop-out rates)	Quantity of water supplied not a good measure of output (similar to SWM, mixed service levels exist depending on per-capita incomes, willingness to pay etc.)
Cost classification	Capital costs (medical equipment, hospital building, ambulances) and Operating cost (wages , salaries and allowances of hospital staff, medicines, hospital accessories, stationeries)	Capital costs (Collection trucks, transfer stations, composting equipment) and Operating cost (labour costs, repair and maintenance of transport vehicles, administration expenses)	Capital and operating costs exist, but can be poor data collection	Costs can be spread over multiple agencies and entities, complicating cost analysis	Capital costs either unknown or difficult to assign to water projects. Operating costs small relative to capital costs.
Developing country challenges	Severe shortage of resources, poor accessibility,low	Identical issues as with healthcare management	Identical issues as with healthcare management	Identical issues as with healthcare management	Identical issues as with healthcare management

	capacity to pay, poorly motivated medical professionals, variety in cost accounting practices				
User fee	Cost recovery through funding from tax revenues for public service providers, whereas private providers cover costs through user-fee collection.	--same--	--same--	--same--	--same--
Multi-input system	Diverse (types of diseases handled are many)	Also diverse (types of wastes handled are many)	Single input system (independent variable: number of passengers travelling; some categories may exist such as senior citizen, student etc)	Single input system (independent variable: number of student admissions)	Single input system(independent variable: quantity of water supplied)
Multi-product system	Provide different types of in-patient and outpatient services	Provides different activities from collection through disposal	Single product system(product= transport from point A to B)	Single product system(product= providing education)	Single product system (product= water)

NGO- non -governmental organisation/CBO- community-based organisation /RWO-resident welfare organisation

Referring to Table 5.1, each of these services can be offered by a public, private or a community organisation. In the case of healthcare, a hospital is the single most important unit or organisation for service delivery, and has been frequently interchanged with the term 'healthcare' in the rest of this chapter. There can be a good mix of government operated (public) hospitals, private for-profit hospitals and private not-for-profit (community) hospitals in a city. Similarly, with solid waste management, it is common to find that developing cities are serviced by one or more of the following three main organisations- the city's municipality or a local government organisation under the public sector category, a private (for-profit) contractor, and a number of 'not-for-profit' self employed or NGO-employed informal sector workers.

The second similarity example in Table 5.1 relates to difficulty in defining the output; this is crucial for cost estimation, and hence output needs to be properly measured. Unlike the cases of industrial or agricultural outputs, it is difficult to define and measure the output for both healthcare and solid waste management. Provision of healthcare aims at improving the patient's health-- something which is ambiguous and difficult to measure (Breyer, 1987). Similar problems in defining the right output exists with SWM. Provision of SWM services aims at improving public health, environmental protection and resource management (Scheinberg et al., 2010b), which in reality is difficult to quantify. As Gottinger(1991) points out, considering solid waste as a homogeneous output and considering tonnes managed as the 'output' for solid waste management, is arbitrary when compared to an industrial output like the number of items manufactured, which is quantifiable. There is still no agreeable consensus for the 'product' or output definition of the healthcare service, but healthcare researchers have identified different proxies such as total number of patients treated, the total number of bed days, and in terms of costs, the outputs would be cost per patient, per patient discharge, per patient day or per hospital bed. The analogous proxy outputs in the case of SWM could be interpreted as total tonnes collected, total population served, while cost outputs are mostly in terms of costs per tonne and costs per person.

The third example in Table 5.1 is that, in both types of services, costs are more commonly classified as capital costs and operating costs instead of as fixed and variable costs. In multiproduct systems such as healthcare and SWM, it is practically very difficult to arrive at a separate cost measurement for the different services provided; the classification of fixed and variable costs will not capture all cost heads. Capital costs connote fixed costs for land, buildings and equipment and sometimes include costs that change with output, but cannot be attached to a single output as they can be spread over different services (examples are privatisation costs, administration costs). Operating costs include those costs directly attributable in the production process, connoting the variable cost, and commonly include components such as salaries and wages, regular maintenance of equipment, consumables and so on.

Next, the challenges faced by service providers in both types of services are very similar in developing countries. For example, severe shortages of resources exist in terms of quantity and quality of labour (medical workers for healthcare and waste management staff for SWM) and capital (medical equipment in the case of healthcare and waste collection and transport vehicles for SWM). Shortage of resources is one of the reasons that a large proportion of both medical institutions and SWM organisations are publicly operated and users have little say if they are unhappy with the service. Apart from shortage of resources, poor accessibility (due to bad roading /transport infrastructure) of low-income-population regions or geographically remote locations in developing countries is another factor for such populations having little or no access to medical or SWM services, when compared to similar populations from developed nations. Another common factor is poorly motivated professionals, especially in the public sector. Salaries are generally below expectations, there are no regular evaluations to assess the performance of workers, and quality check inspections are challenged by issues such as corruption at supervisory staff levels. Information collection and management (accounting practices) are varied and datasets with sufficiently detailed information on costs in developing countries have been difficult to come by. Not only are health care systems similar to solid waste management systems in this respect; practically all services (eg, transport, electricity) in developing countries suffer from similar problems.

When public service providers such as the municipality of a developing city provides healthcare or SWM , a large proportion of medical and SWM costs are not recovered directly from patients or households. . Costs are either covered by a combination of public insurance programs and funds collected from general tax revenues (to finance public hospitals), or mostly from funding through property tax revenues (for municipally serviced SWM) from all tax-payers in the city. But when certain areas of a developing city is also serviced by private providers, especially by not-for-profit organisations like community-based or resident-welfare organisations that have little or no financial support from the municipality, populations in those areas need to pay additional user fees for the same services. How to divide the line between private and public services for a uniform user-fee rate in developing cities remains to be explored.

In the world of healthcare, as developing cities progress due to industrialisation, there is a gradual shift from treating infectious diseases to more life-style related diseases. This can be attributed to improvements in average standards of health but associated with higher stress levels resulting from better paying incomes. Similarly with solid waste management, as cities become more industrialised and average income levels rise, the characteristics of waste produced shifts from having more organics or putrescibles to an increase in recyclable content such as plastics and packaged materials (similar to waste characteristics of developed nations). Most developing cities are midway through this industrialisation phase and in a situation where diverse diseases or diverse waste types are simultaneously prevalent.

In the final example, both healthcare and SWM are multi-product public services. Healthcare management can involve a number of different types of curative services, similar to the different types of solid waste services from collection through disposal. The main objective of the healthcare system is to provide patient treatment. This objective is achieved through the provision of two broad services or activities- outpatient treatment (treatment without being hospitalised) and inpatient treatment (treatment while being hospitalised for more than a day). In a developing city these activities can be handled by different types of hospitals (for example: public, private or community), can have different sub services (example: emergency departments for outpatients or operating theatres for inpatients) and have intermediate medical functions (example: pharmaceutics and diagnostic facilities). SWM is also a multi-product system consisting of two broad activities of collection and treatment/disposal of waste. These activities in a city can be shared between the municipal and non-municipal organisations, can have different sub services (such as door to door collection and collection from community bins or disposals in engineered landfills and open dumpsing sites), and have intermediate functions (such as treatment units or transfer stations), similar to the multi-product characteristics of healthcare management.

5.2.2 Healthcare management research results and analogous SWM research directions

There have been many published estimates of cost functions for the healthcare management sector; a few examples are listed in Table 5.2. Researchers have used different sources of data, different time periods, and data on hospitals from a variety of areas in a country. These studies also reflect different approaches to control for costs or measure variables hypothesized to influence costs. The quality of both the data and the estimation techniques have improved with time. Despite these differences, however, many of the empirical findings are consistent across healthcare cost function studies.

Table 5.2: Selected healthcare cost function analysis examples

Reference	Number and (source of data points)	Time period	Variables	Cost Function
Adam et al, 2002	49 hospitals from developed and developing countries	1973-2000	*UCi* is the natural log (ln) of cost per bed-day in1998 international $ in the *ith* hospital; X_1 is ln of GDP per capita in1998 I $; X_2 is ln of occupancy rate; $X_{3,4}$ are dummy variables indicating the inclusion of drug or food costs (included= 1); $X_{5,6}$ are dummy variables for hospital levels1–2 (the comparator is level 3 hospital); $X_{7,8}$ are dummy variables indicating facility ownership (comparator is private not-for-profit hospitals); X_9 is a dummy variable controlling for USA data (USA = 1); and *e* denotes the error term.	UCi $=\alpha 0 + \sum_{i=1}^{n} \alpha i X i + e i$
Anderson (1980)	75 Kenyan hospitals	1975-76	C= average cost per patient day, SCALE = a measure of hospital potential capacity (proxy used: number of approved or set up beds), OCR = occupancy rate expressed as a percentage of SCALE, ALS = average length of stay, TOPPD= total outpatient visits per inpatient day, SAT= satellite operations(no. of smaller administrative hospitals operating under district	In C = $\ln a_o + a_1$ In SCALE + a_2 In OCR + In ALS + a_4 In TOPPD + a_5 In TOPPD + $a_5$ln SAT + a_6 PHD + u where each a_i represents a constant elasticity estimate of the dependent variable with respect to the i_{th} independent variable; u represents a random error term; and C, SCALE, OCR, ALS, TOPPD, SAT, and PHD are as previously defined.

			hospital umbrella), PHD: (= 1 ,if a provincial hospital; =0, if a non-provincial hospital)	
Dor (1987)	19 urban public hospitals in Peru	1984	C/A= Total cost/total number of admissions, F= caseflow (number of cases treated), OUTP= no. of outpatients visits, %DEL = proportion of admissions taken up by deliveries, %SURG = the proportion of cases receiving surgery ,MIN =a dummy taking value of 1 if the hospital is under the control of the ministry	$C/A = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 OUTP + \alpha_4 \%DEL + \alpha_5 \%SURG + \alpha_6 MIN + v$

The objective of this section is not to provide a review of the cost function analyses from healthcare literature as there are already a number of excellent review articles on that topic (Lave and Lave, 1984; Cowing et al., 1983; Mann and Yett, 1968; Ermann, 1988; Newbrander et al., 1992; Hefty, 1969). But instead we try to understand the basic intent of these investigations and, because of the similarities in characteristics of healthcare and SWM, develop research questions for similar cost function investigations for solid waste researchers. The current focus is on developing countries. Although waste researchers have also studied some of the questions in this section, those studies are limited because of their focus on developed countries (for details refer to Chapter 2 of the thesis). However, where appropriate, the methodologies used in some of these studies might be useful in answering MSW research questions, and hence some examples of those methods are provided in this section.

5.2.2.1 Economy of scale

An economy of scale is said to exist when average cost decreases as production increases. Early healthcare researchers were interested in determining whether economies of scale existed in hospitals ; they believed this to be useful to answer questions related to planning of the service. The relevant questions that healthcare researchers addressed to evaluate whether economies of scale existed or not were- How do hospital costs behave when the scale of hospital operations expand, while holding the services offered in the same proportions? Would unit costs increase, decrease, or stay constant as hospital operations expand? Is there an optimally sized institution (hospital)? Results for economies of scale for hospitals were reported as follows: "Studies from North American hospitals have suggested that economies of scale may exist up to 250 beds and that diseconomies of scale may set in at about 600 beds"(Lave and Lave, 1984). Or "Alba (1995) conducted a cost function analysis on 65 hospitals in the Philippines and found that the optimal (bed) capacity was at about 85 beds". What this meant, for example in the study by Alba, was that if the scale of hospital operations were doubled, long-run per unit costs of hospitals with fewer than 81 beds would decrease, while those with more beds are likely to see higher per unit costs. There was another way that researchers used the economies of scale result. For example, Anderson (1980) found economies of scale in the 75 government hospitals sample from Kenya. The author concluded that because cost savings were moderate (that a 1% change in bed capacity can yield a 0.24-0.25% change in unit costs), it was better to expand existing facilities instead of building a new small-scale hospital. Results such as these were thought as being useful for planning and decision-making.

Analogous research questions for SWM

A common planning issue for SWM in developing countries is related to expansion of the service. With rapid population growths in urban areas in and around developing cities, service providers, mostly municipalities, need to expand current SWM operations to include more areas. The question of whether or not it is cost-effective to do so can be answered by studying the economy of scale for the service.

Is privatisation a cost effective option when based on optimising the existing collection services offered by MSEs, CBOs and waste-pickers in a developing city? How does the cost vary with the quantity of waste collected if small private waste collectors are merged?

Economists have suggested that economy of scale depends on how capital-intensive a particular industry or service might be; capital-intensive services exhibit significant economies of scale due to higher fixed costs (Bel, 2012). With this in mind, it would be a good idea to separately evaluate the levels at which economies of scale are exhausted for solid waste in developing countries, activity-wise, as some activities are more labour intensive and some others capital intensive. For example, for waste collection in developing countries, economies of scale might be exhausted soon due to the more labour-intensive nature of the activity, than, say, secondary collection and treatment activities that involves bigger capital investments such as transfer stations and composting plants.

Constructing a cost curve is a simple way to examine the economies of scale effect for SWM (USEPA, 1997). The two types of data needed to examine scale economies are the unit costs of an activity (generally the per tonne cost) and the scale of that activity (generally in tonnes per day). Figure 5.2 is an example to demonstrate the effect of economy of scale. In Figure 5.2, economies of scale are strong between 100 and 1000 tonnes and begin to level out thereafter, suggesting to a waste planner that 1000 t/d might be a good minimum to target to improve efficiencies.

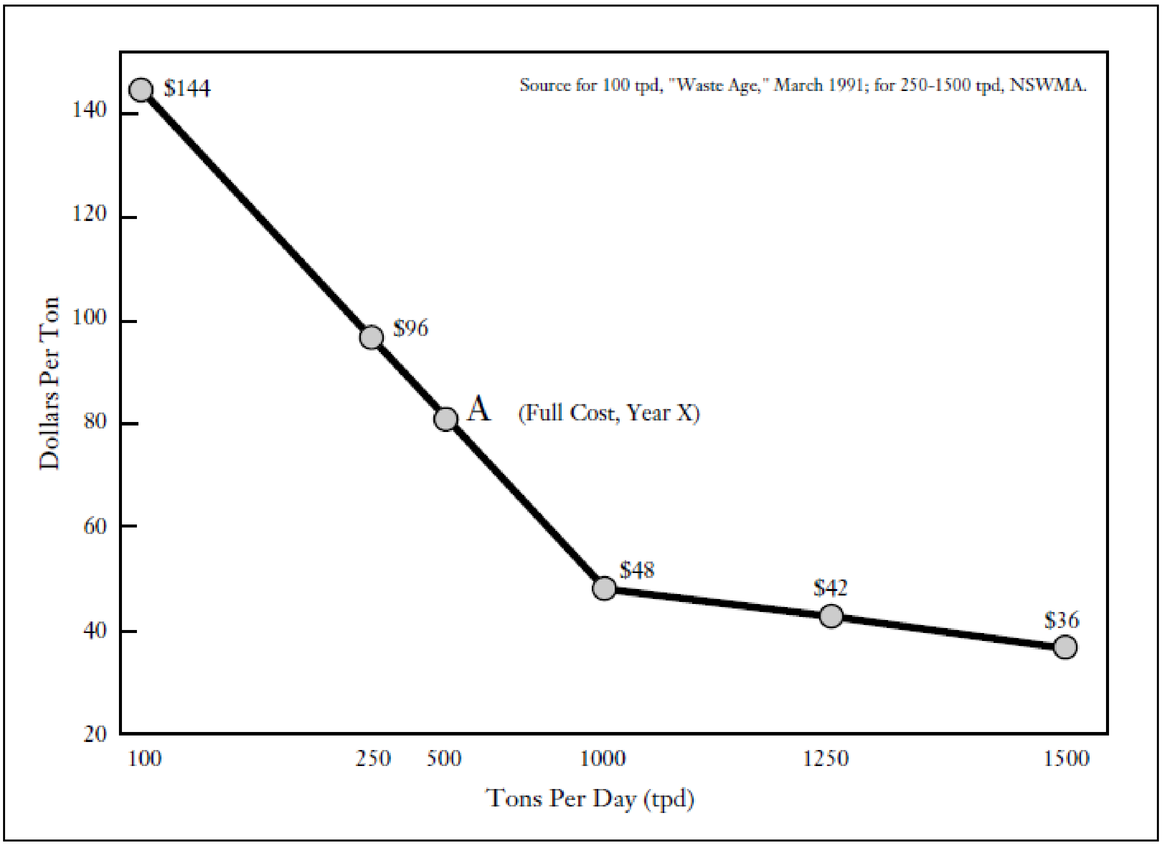

Figure 5.2: Example showing the economies of scale effect for a solid waste activity (USEPA, 1997)

Starting with the seminal works of Hirsh (1965) and Stevens (1978), waste economists, such as Kinnaman, Bel, Bohm, and Dijkgraaf are now using advanced regression methods similar to that used by healthcare economists to examine scale economies for SWM in developed countries (some of these earlier studies are detailed in Chapter 2 of this thesis). The advanced methods are beyond the level of potential application given the present limitations in developing country datasets, and hence are not discussed here.

Although pioneering works on statistical cost functions in the healthcare sector were primarily undertaken to explore the economies of scale issue, as research progressed, healthcare researchers realised that economies of scale were not so relevant in the real world. Wagstaff and Barnum (1992) fine-tuned this issue by refining the problem to not whether outputs should be expanded to fully utilize the fixed inputs, which is a question of economies of scale, but whether optimal amounts of the fixed inputs are employed *given the output levels of hospitals*. In other words, the question is whether hospitals are allocatively efficient in their use of the capital. Nevertheless, determining economies of scale still provide the health planner with other valuable information, such as, determination of appropriate facility size and applicable rates of reimbursement. These are both generally based, in part, on the relationship between the scale of operation and the associated unit cost of production. Similarly, for SWM in developing countries, answering the economies of scale question could help with expansion planning programmes for a start, and then lead to assistance with other planning questions.

5.2.2.2 Marginal costs

Marginal costs is the change in total variable costs incurred when producing each additional unit of output. *Marginal* means a first derivative. Marginal Cost or MC= $\Delta TC/ \Delta Q$, where TC= total cost, and Q= quantity of output. In the case of non-tradable goods or services, depending on how resource-need varies during a particular time period being considered, marginal costs include all costs that vary with the quantity of output; all other costs are considered as fixed costs. For example, if the total cost of General Practitioner (GP) services for treating 10 patients is 50$ per patient, in the flu-season, the total cost of treating 20 patients might rise to 60$ per patient. The marginal cost of treating additional patients in the flu season is estimated as an additional 10$/patient (due to expenditures on additional flu-shots and nurse-hours), and not an additional 50$/patient. This is because certain fixed costs such as receptionist's salary, daily cleaning of premises and power supply will not have any effect on the additional patient flow.

Healthcare researchers have clearly distinguished between estimating marginal costs (the cost of producing an additional unit of output) and average costs (the total cost of all units divided by the total units produced). Since fixed costs cannot be avoided, it was deemed more important to estimate marginal costs than average costs for future planning. Economists have shown that marginal costs will be lower than average costs so long as the capacity created by the fixed cost is not fully utilised(Kurup, 2010). If economies of scale exist up to a certain level in the production of hospital services, the average and marginal costs will fall up to this level succeeded by diseconomies. Estimating the link between scale of production and average and marginal costs help in planning to take advantage of scale up to the point at which they begin to rise(Kurup, 2010).

Healthcare researchers estimated marginal costs and studied its relationship with average costs to develop appropriate revenue-raising tools. At the beginning, the reason for estimating the increased cost of admitting additional patients was the development of appropriate user-fee rates. But more recent interest in studying this relationship is for budgeting purposes, i.e to answer the question " Are costs increasing more or less proportionally than admissions? Pricing and budget recommendations using marginal cost figures in the healthcare sector suggest that if costs increase less proportionately than admissions, then allowable budgets should reduce and vice-versa, and for short term increases part-time employees could be hired (Lave and Lave, 1984).

Early healthcare researchers measured marginal costs by analysing weekly or monthly time series data of a hospital. A cost function developed using such data presumes that all other variables such as capital equipment, quality of care and staffing patterns remain unchanged over short time periods. As a result, the cost function essentially measured a single variable- the change in the occupancy rate over the specified time period, holding all other variables constant. The resulting coefficient estimated the marginal cost of the additional patient-day or patient.

Analogous research questions for SWM

If a developing city's average SWM cost is a certain *x* per tonne, and if the city experiences a significant increase in the quantity of waste due to a programme change, it is unlikely that that the costs would increase by *x* for each extra (or marginal) tonne managed. That is so because the average cost would contain certain fixed costs, such as wages of salaried employees, which will not be affected by the amount of waste collected.

The relevant questions to ask would be, which costs will change and which costs won't when making changes to the solid waste management system? If average costs are a certain amount, what are the marginal costs?

Developing a cost curve as before for exploring economies of scale is one way to estimate marginal costs for the short run, as capital costs will be constant and the coefficient of the waste quantity will provide a reasonable estimate of marginal costs. However, in the long run, estimating the marginal cost becomes complicated as the cost function becomes multi-variate and needs a thorough understanding of the specific variables that will contribute to cost changes when changes are made in the SWM system.

By long-run we refer, not to the specific measure of elapsed time, but to the period over which different types of resources can vary. Consider a municipality that is planning on expanding its services to include areas surrounding the present municipal limits. If the extra tonnage to be handled can be managed by existing capital equipment, certain fixed costs that are not affected by the amount of garbage collected will not contribute to marginal costs. Examples are overhead and central administration costs, salaries of full-time employees, time taken in sending trucks and collection carts to and from the place stored overnight etc. Examples of costs that might contribute to marginal costs could be , employment of part-time collection workers, additional maintenance costs due to increased wear on vehicles from the extra tonnage, extra tipping fees, additional cost of fuel due to increased coverage and so on. However, if the service is expanding to the extent that an additional five trucks needs to be purchased to transport waste, the marginal cost should include the purchase of those trucks. Certain external factors such as commitment by ground staff and supervisors, poor cooperation from service users, truck sizes and configuration, can significantly affect marginal costs estimation.

Most developing countries are unable to sustain an acceptable level of service due to poor cost recovery rates (Diaz et al., 1996). This can be partially blamed on inadequate planning. If waste quantities are accurately predicted due to either an expansion programme or due to programme changes such as increasing informal recycling rates, estimating marginal costs could be most useful in recovering costs by making appropriate pricing recommendations. Predicting accurate waste quantities is slightly easier than predicting patient flow in hospitals. If a marginal cost curve could be developed, it could help in setting appropriate user fees as a cost management measure in developing countries.

5.2.3.3 Economies of scope

Economies of scope are said to exist if the joint output of a single organization is greater than the output that could be achieved by several separate organizations each producing one product but together employing the same amount of input. An implication of economies of scope is that production costs can be reduced by producing products jointly, rather than specializing.

Healthcare economists have frequently explored the questions: Should hospitals specialize or provide a broad range of services? Is it more or less costly to provide inpatient and outpatient services in a single hospital or by two specialised hospitals?

If scope economies were detected using cost function analyses, policy recommendations were made to combine activities- for example, to have both hospital departments such as surgeries and emergency care in one hospital. On the other hand if the result was opposite, i.e., if departments were more expensive to maintain jointly, it could be recommended that these be offered by two different and specialist hospitals.

Healthcare studies indicate that the functional form of the cost function is important when exploring economies of scope. The study by Wagstaff and Barnum (1992) specifically focussed on exploring scope economies for four developing countries, namely Kenya, Peru, Ethiopia and Nigeria. They state that specifying an average cost function which considers the overall total costs as the sum of the product-specific total costs (i.e. sum of inpatient and outpatient costs) is not effective in measuring economies of scope. Specifying a multi-product cost function, i.e a cost function that jointly considers inpatient and outpatient services has proven to be more effective by healthcare researchers in general as it measures the source of economies of scope which is a characteristic known as 'cost complementarities' (meaning that the marginal cost of producing one output would decrease as the quantity of the other good is increased). To allow for cost complementarities the cost function would need to include interaction terms between various outputs.

Analogous research questions for SWM

Similar to healthcare, multiple service providers are involved in SWM in developing countries. Some private service providers are involved in collection of waste, whereas some others provide the whole service from collection through disposal. The solid waste researcher might be interested in answering the following questions related to 'vertical' integration of the service to explore the scope issue for developing countries-

Do economies of scope exist between the various services used in SWM? Does average cost decrease as the number of activities (from collection through disposal) produced by the same infrastructure increases? Will costs per tonne be greater if (1) each service provider handles a separate SWM activity (say if NGOs handle collection, private contractors handle transportation and municipalities handle landfilling)?

Municipalities can be thought of as multi-product companies because they generally handle two or more services (other than SWM) simultaneously. Grosskopf and Yaisawarng(1990) believe that the multi-product nature of municipalities is characterised by existence of economies of scope, i.e., they achieve cost savings when joint services are provided.

A related question might relate to 'horizontal' integration: Is there a benefit from merging two private collection companies into one or does this reduce competition too much?

A good example of the method used to evaluate the economies of scope question can be found in the study by Callan and Thomas (2001). They studied whether economies of scope existed when both disposal and recycling services are jointly provided in a sample of 110 municipalities in Massachusetts. Similar to the method used by healthcare researchers, the method used by Callan and Thomas also involved including an interaction variable which was the product of the outputs (in their work it was the quantities of waste disposed and recycled) , among other explanatory variables. They included this interaction variable in both the disposal and recycling cost functions (estimated separately), in order to study the cost effect of the alternate service . A negative coefficient for the interaction variable was an indication that economies of scope were present in that study. The method might be useful for similar studies for developing countries. The reader is referred to that paper for a detailed understanding of the method and type of data used.

5.2.3.4 Relationship between size of service provider and costs

When studying the relationship between hospital costs and size, it became necessary to control for the variety of illnesses (commonly termed 'case-mix' variation). This issue arose when researchers tried to answer the question "Are larger hospitals more or less efficient than smaller hospitals in terms of costs per day or per unit of inpatient service?" The question was more complicated to answer than envisaged, since larger hospitals also treated more complex illnesses. The appropriate method to control for the sheer number of diseases and conditions when estimating a healthcare management cost function, is still an unsettled issue in cost function analyses literature. Early literature relied on surrogate

measures by measuring differences either by the type of services offered by the hospitals or by the types of intermediate facilities available within the hospital (ex. blood banks, pharmacies, canteen). As research progressed more sophisticated direct measures for case-mix were developed by forming groupings based on diagnosis, type of surgery, patient age and so on, that resulted in advanced cost function estimations (Lave and Lave, 1984).

Analogous research questions for SWM

The issue of service provider size is one that is quite complex to study even for SWM. The variation in quantities and characteristics of wastes handled and different activities performed by different service providers, results in a very complex system and is probably the reason for little or no intervention on this topic in available literature. In developing countries, SWM service providers come in various sizes and also have multiple responsibilities alongside waste management. For example, service providers can range from large municipalities servicing over a million residents in a city while also providing other responsibilities alongside SWM such as water supply and sewerage, to small resident welfare organisations exclusively collecting waste from limited number of households, say about 100 households or so. It is, no doubt, challenging to decide the best combination of service providers in a developing city. Unlike the healthcare sector, no attempts were found in available literature that tried to control for the type of waste when developing SWM cost functions. Waste researchers might want to try to answer the following question in order to study the relationship between size of service provider and costs:

When controlling for the type of waste handled, (examples include medical waste, hazardous waste, industrial waste, residential , commercial waste, institutional waste), how does the size of the service provider affect costs?

Answering questions such as these might be useful for decision makers in developing a mix of small to medium sized organisations to ensure competency amongst service providers, especially when involving private sector providers.

5.2.3.5 Accounting for outpatient activities and informal sector activities

The most important 'output' or 'product' in the healthcare system of service is treating patients. And the two main cost-incurring paths in producing this output are inpatient and outpatient care. Outpatient care is when the patient is treated without being hospitalised; in a general practitioner or physician's office. Although, in general, inpatient care (especially if involving an overnite stay) costs more, a hospital that has significant outpatient activity will spend more than one that does not (Lave and Lave, 1984). And healthcare researchers have thought of outpatient activities as an important variable to measure, or account for, in a cost function. Depending on the nature of the data available, researchers either control for outpatient activities as dummy variables, include it as an independent variable for total cost estimation, or subtract it from inpatient costs when using inpatient cost as the dependent variable. Other more advanced econometric adjustment methods for outpatient activity are also available these days that are beyond the scope of this chapter.

Analogous research questions for SWM : Informal sector costs

Similar to healthcare, there are two cost incurring paths for a SWM system in a developing country. The land disposal path consists of materials that end up at a dumpsite, and the informal recycling path consists of materials that are utilised for a commercial return. In general, the costs incurred in each path are due to one or more of the activities namely collection, transfer, transport and processing. Although some attention has been directed towards developing cost functions for the land disposal path for developing countries (see

Parthan et.al 2011) as this is the business of the more formal service providers and cost data are somewhat available, little attention has been devoted to doing the same for the informal sector path . Much like the healthcare sector where inpatient care is more costly when compared to outpatient care, in the case of SWM the landfill path is surely a more expensive affair when compared to the informal recycling path. And like the healthcare sector where outpatient care is a major component of the system that cannot be neglected, in SWM the same can be said about informal recycling.

For a start, some research questions that waste researchers could address under this topic are-

What are the cost components of informal recycling costs? Is there a direct or inverse relationship of informal recycling costs with associated formal waste collection and disposal costs? Is there an optimum level for recycling?

Often source separation measures are planned to be introduced in developing countries for better management of waste. Advanced research studies on informal sector costs could try to answer the following: If source separation is introduced, how would the marginal costs of collection, processing, and market price of recyclables change?

5.2.3.6 Input prices

The prices that hospitals need to pay for their inputs (personnel, supplies, drugs) have an effect on costs. To control for factor prices when developing cost functions, healthcare researchers incorporate dummy variables for regions, population divisions (example, less than 500, greater than 1 million etc.) and whether it was an urban or rural location. Data on factor prices are rarely available and most cost function studies requiring control over factor prices are crude, especially with developing countries, where the only information available is on wages of employees. Using wage rates, sometimes crude indexes of factor prices are arrived at, such as the wage bill per full-time employee. The studies controlling for factor prices have shown that costs increase with city size, but it is still unclear what exactly the city size variable is measuring (add reference). Lave and Lave (1984) speculate that "the prices of factors of production other than wages could increase with city size, in which case the coefficient is reflecting factor price differences. Alternatively, the nature of the demand for hospital care could vary, in which case the coefficient could be reflecting some unknown product differences."

Analogous research questions for SWM

Analogous to healthcare, SWM costs for different regions within a developing country, between developing countries providing the same level of service, or during different time periods will differ due to variations in input prices for labour, capital equipment and fuel for transport vehicles. Accounting for input prices becomes important for a fair comparison.

Solid waste researchers might want to answer the following question in order to incorporate variations in costs due to factor or input prices:

What is the relationship between SWM costs and variables of interest such as privatisation, user fee revenues etc. , while controlling for input prices?

Data on input prices might not be readily available for SWM. While input prices are best obtained from service provider datasets, any additional information could be sought through questionnaires. Generally data for number of employees and their corresponding salaries of employees might not be difficult to obtain, especially for municipal employees. The price for labour could be roughly calculated by taking the ratio of the total salary expenses to the number of employees. Capital price could be obtained by dividing depreciation costs by capital stock. If input prices are included along with other regressors, that would hugely improve the quality of cost functions.

5.2.3.7 Ownership and control

Healthcare service providers can be broadly classified as public, private and community. The question that healthcare researchers tried to address is whether one type of ownership was more efficient than the other, other things being equal. Is the cost of a hospital day in, say, a public hospital lower than a private hospital of the same size? This question is very sensitive to how the cost and output data are standardised across different institutions, and results available in the literature are contradictory.

Analogous research questions for SWM

Similar to healthcare, the type of ownership varies widely for SWM in a city. The type of ownership in SWM could be an important variable to consider when estimating costs via a cost function analysis. Over the yearsin developing countries, privatisation has been encouraged, public private partnerships have been promoted, and intermunicipal alliances have been suggested for the more capital-intensive activities such as building engineered landfills (Zhu et al., 2008), but no detailed analyses are available in literature that provide strong evidence in terms of cost for a particular type of ownership. The question that researchers could consider answering in order to determine cost effectiveness of one type of ownership or organisational form over another is--

While controlling for other variables, is the cost per tonne of one type of ownership of the service provider lesser than the other? Are larger service providers like a multinational private firm more or less efficient than an NGO in terms of costs per tonne, while controlling for types of waste handled and activities involved?

The above issue has in fact been debated by researchers for some developed countries. Waste researchers have arrived at contradictory results (Bel et al., 2010), similar to what healthcare researchers have experienced. For example, Stevens (1978) found that private firms were more costly when compared to public-private joint ownership and attributed this to higher billing costs borne by the private firm. Others like Dubin and Navarro (1988) and

Callan and Thomas (2001) do not find lower costs with private delivery, but have not explored the details. Bel et al (2010) have used an approach known as 'meta-regression' in order to assess these contradictory studies and arrive at a more generalised result. Their study investigates whether private delivery is less costly than public delivery when controlling for other attributes. Interestingly, their dataset compiled all previous studies in literature that tried to answer the ownership vs. cost question. Their approach uses a linear equation in which the dependent variable was the t-statistic for the coefficient of the dummy variable of private delivery; used to measure the cost differences under public and private ownership. The explanatory variables were related to the common characteristics of other studies found in literature that explored the ownership question such as year, country or type of service. A negative coefficient for an explanatory variable meant that studies with a higher value for that variable are more likely to find cost savings from private production and vice-versa. They do not find concrete evidence that one type of ownership achieves more cost savings over another and conclude that future research should instead be directed towards the the cost characteristics of the service, transaction costs involved and the creation of a policy environment to stimulate competition. For more literature on this particular topic and other approaches used to study the ownership issue, readers might wish to go through the literature review part in the paper by Bel et al (2010)

5.3 Data categories and SWM cost functions in developing countries

The basic purpose of a cost function is to summarise the relationship between costs and output. For SWM, the output is best quantified as tonnes of waste managed during one or more activities from collection through disposal. Depending on data availability and the problem in hand, a SWM cost function could be formulated for one or more solid waste activities during one or more time periods using data from one or more service providers. The ultimate objective is to develop a cost function $C_{i,t} = f_{i,t}(Q)$, where $C_{i,t}$ is the level of SWM costs (total, per tonne or per person depending on the model specification) of a service provider i in time-period t and Q is the output in tonnes of waste managed. This would account for the differences in SWM output due to variations discussed in the previous section. An econometric technique such as multiple regression is a good method to analyse cost functions.

Until data accounting procedures reach a certain standard for SWM cost function estimation in a developing country, waste researchers will need to find ways to work with available data. The objective of this section is indicate to the reader which analyses discussed in the previous section will best suit a particular form of dataset that are generally available from developing country's service providers.

5.3.1 Data from a single service provider

Under this category, the relationship between costs and tonnes managed could be determined for a single service provider, say a municipality, for a short period of time. The time period could be over a few weeks or months, but ideally should not exceed over a year. The weekly or monthly data available or collected over a short time period is assumed to remain constant; meaning that other than the tonnes managed, other factors such as prices of consumables, number of labour employed and so on will not vary much in the short term.

This method of using weekly or monthly cost and waste data from a single firm essentially models a short-run cost function. Such a cost function can be used to determine the characteristics of the short-run variation in costs. In economic jargon, this means estimating the marginal cost of an additional tonne of waste managed (per day mostly), given the capacity of the service provider. Decisions such as whether or not economies of scale exist can be exploited for future planning can be based with short-run cost data.

5.3.2 Data from many service providers

The second type of model that could be constructed could help measure the differences in characteristics of a similar set of service providers or different types of service providers, during a specific period. The cost function of service provider i, C_i, would be represented as a function of the *characteristics* of the service provider that would result in different costs.

This type of model should hence be based on data from service providers during a particular period. The cost would possibly vary depending on characteristics such as the type of service provider (if the dataset contains different service providers), frequency of collection, density of population/housing of service areas, price of labour, public-private partnerships, type and quantity of capital available, quantities and characteristics of waste handled, amongst others. All of the research questions formulated in the previous section could be evaluated , albeit separately, if data on the characteristic variables are available or collected from each service provider.

5.3.3 Mixed Data

The data under this category can be from a variety of service providers and from different time periods. The types of models developed using such data would potentially be able to model more complex real-world systems. However, this will require major data standardizing efforts. Although this type of data will be most easily available, it requires sophisticated modelling techniques to develop a cost function from such data. Hence such data must be handled by someone who is familiar with microeconomic modelling. Following the footsteps of healthcare researchers in developing more sophisticated cost functions for that service, methodological formulations that take into account the usual assumptions of production technologies should be adopted for developing SWM system models. For example, the flexible functional form of cost function that regresses total costs on output quantities and input prices are more consistent with economic theory of production since they reject the concept of a single aggregate measure of output. Or the more recent hybrid flexible forms that include explanatory variables in addition to output quantities and input prices are also useful from a systems perspective. Another functional form is the translog specification which provides a more theoretically appropriate framework, i.e., it enables an explicit determination of marginal costs given the structure of output and input prices that might affect the structure of costs (Kurup, 2010). A more detailed discussion of the above estimation techniques are not discussed here and would need a better understanding of microeconomic theories, which is beyond the scope of this chapter, and can also be found in standard economics textbooks.

5.4 Conclusions and recommendations for future progression of cost functions studies for developing countries

What seems evident from the healthcare management experience, is that there are three broad objectives of cost function research. One objective is to address planning issues such as optimum size and scope of the service, and estimate marginal costs. Another is to develop a better understanding and measure explanatory variables for cost differences between hospitals and increase in healthcare costs over time. The final objective is to be able to refine healthcare cost functions using more sophisticated econometric techniques to model them as close as possible to the real world.

Similar to healthcare cost functions, the estimation and interpretation of existing SWM cost functions (modelled for developed country scenarios) constitute an attempt to study, under a set of assumptions, the structure of costs and production for effective service provision. Although there has been more contribution to the development of cost functions in developed countries in the last decade or so , the number of studies do not match up to the work done by healthcare researchers.. If more such studies could be started for developing countries too, then that would be a big step towards ensuring that scarce resources are used to best effect. Developing a financing strategy that will help to cover all or some of the costs involved in SWM should be the goal of the cost functions for developing countries, as financial resources for smooth provision of the service are hard to come by.

5.4.1 Variables analysis

It is of first and foremost importance to know how SWM costs in developing countries are influenced by output levels and other variables such as privatisation, user fee revenues etc. Such attempts need better understanding of the determinants of solid waste costs. One line of research should be directed to understanding the factors that affect the relationship between costs and tonnes managed. Some important ones such as facility size, ownership type and informal sector involvement have been discussed in Section 2. Economic variables expected to affect costs of SWM include costs for labour, capital and fuel, and these also need to find their way into a cost function. Interpreting the least square regression of costs on variables could reveal which coefficients are positive and significant in the waste equation. Additional questions could be answered such as by what percent would costs increase due to a 1% increase in each variable affecting costs.

5.4.2 Optimising service provision

The second line of research could be directed towards understanding cost conditions that influence the patterns of production and governance of the service. This means exploring whether or not economies of scale and scope exist so as to obtain optimum service levels.

For a recent review focussing on this particular objective of cost function research, for capital intensive services like SWM amongst others, refer to Bel (2012).

5.4.3 Improving econometric techniques

The third line of research could be directed to the development of more sophisticated econometric techniques. Similar to the early experiences of healthcare, it is natural to start with simple cost functions that will surely be unable to capture standard microeconomic theory assumptions. As research progresses and data quality improves, it would be natural to refine existing models or develop more sophisticated models that would capture the complexities of the solid waste systems in developing countries. Other forms of cost functions over simple linear forms, such as the flexible functional forms, hybrid flexible forms and translog forms, that account for the multiproduct nature of the service will be needed and can be a topic for future research.

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CHAPTER 6: CONCLUSIONSAND OPPORTUNITIES FOR FURTHER WORK

6.1 Foreword

This thesis is written in a different style. It is similar to the traditional style thesis in a broad sense, except that the research results are packaged as four discrete units or contributing chapters; two of which are published manuscripts, and two more are in a form suitable for publication in scientific journals. Each contributing chapter had its own conclusions and discussion of limitations and recommendations, along with an abstract, introduction, methods, and results.

The aim of this chapter is to provide (1) an overview of the major findings from the research as a whole, (2) a detailed description of the implications of health care analyses on the Chennai case study, which in turn demonstrates the way forward in terms of the most important data that needs to be collected and future cost analyses that needs to be conducted, (3) constraints, challenges and limitations that future researchers need to be aware of, (4) a summary of the specific contributions made in this thesis, and (5) a note to engineers ,working on other civil engineering management systems, on how this work can be used and improved.

6.2 Major findings

When it comes to municipal solid waste management, the need of the hour in transitional economies is to expand existing services to serve increasing populations and also to raise the level of service provided, while making sure that constrained financial resources are effectively managed. It was recognised in this thesis that the real need is to improve cost estimation for municipal solid waste management in transitional economies. The research found a great amount of SWM data for India, and focussed on India because it provided both a wide variety of urban areas experiencing the waste challenge while also providing costs in a consistent manner.

One of the major findings from this research was that achieving cost efficiency for the service was being hindered in countries like India mainly because cost decisions lacked rational justification, and were mostly based on experience-based techniques, such as rule-of-thumbs. Traditional cost estimation methods were not found to be suitable when planning improvements for coverage and service levels in industrialising regions (for a summary see Table 6.1).

Table 6.1: Existing cost planning approaches in industrialising regions and their suitability

Approach	Description	Applicability in cost planning	Problems
Unit Cost Method (UCM)	Disaggregates each SWM activity (eg. collection, disposal) into separate items (eg, salaries, fuel costs), notes the required quantity of each item, multiplies this with the cost per item or unit cost (developed from existing datasets or taken from price quotes) to arrive at the total cost	If population of an area or the total waste collected in an area is known, the average costs per capita or per tonne are calculated. To predict future investment needs, these per tonne or per capita values are multiplied by the projected quantities of wastes or population	laborious, more suitable for preparing initial cost estimates, hard to incorporate changing conditions of cities
Benchmarking	Uses actual (or average) cost data from a similar organization that has made a change of the type under consideration	Same as above	Carry-over of previous dataset problems, if any
Application of cost models developed for industrialised countries' waste systems to industrialising regions	Develops (using principles of statistics, economics, linear programming etc) a relationship between costs and factors affecting costs	Useful to evaluate cost impacts due to changes in individual factors	Varying levels of complexity, unsure of material flow under which system was modelled, difficulty in translating from one set of conditions to another

With historical cost data, one can estimate costs using the first two approaches in Table 6.1. However, the use of these costs in planning is questionable because, unless one knows what they are for, it is risky using them for planning other than as broad brush indicators. The cost modelling approach, on the other hand, especially the ones using cost functions, are useful in pursuing the main objective of this thesis, i.e., "analysing cost information in a way that facilitates planning for improving coverage and service levels for a developing country" (Chapter 1, section 1.1).

Evaluating cost determinants and optimising service provision are the two new classifications introduced in this thesis for cost function research in developing countries (Chapter 5, section 4). The first objective, i.e. evaluation of cost determinants, was studied using data from a number of service providers, through the 300 municipalities' NIUA dataset in chapter 3. The second objective about optimising service provision was studied using data from a single service provider, the Chennai municipality's dataset in chapter 4, by developing cost yardsticks and marginal costs.

Readers are asked to note that results from the data analyses in chapters 3 and chapter 4 must be extended with caution. This research, being the first of its kind for developing countries, encountered a number of issues with data. The main lesson to be learnt is that there is value in conducting cost function analysis for a developing country and city, and the methodology adopted in developing cost functions in those chapters could be refined with better quality data.

The extensive cost function research that has progressed for the last three decades in the healthcare management sector showed that existing SWM cost function research was just a drop in the ocean of the cost function research that is being conducted by healthcare researchers. One major conclusion of Chapter 5 of this thesis is that health care studies show ways to analyse costs that have not been fully applied to solid waste management (such as exploring economies of scope, and studying relationships of costs with factors such as service provider size, informal sector involvement, factor prices, and ownership). Health care studies also include analysis of topics that have been studied in this thesis(such as assessments of economies of scale and marginal costs). Specific data needed to perform those analyses are a constraint at present. The links between ideas provided in Chapters 4 and 5 to collect and analyse data will be useful to further research on this topic. They are explored in a separate section that follows.

6.3 Implications of health care analyses on the Chennai case study

Considering the Chennai dataset as a example, it would be valuable to see how the lessons from the healthcare study could be applied to Chennai, and the potential problems, and what in turn that implies about the need for further work.

6.3.1 Economy-of-scale and marginal costs

In Chapter 4, economy of scale and marginal costs were evaluated for Chennai' formal service provider (namely CoC), albeit for the short-run only. This was because Chennai's dataset contained only operating and maintenance expenditures that were evaluated against waste collected using existing plant and equipment. In reality, as the city grows, solid waste capacity would be enlarged periodically by making additional capital investments by, say, purchasing additional trucks, hiring additional full-time employees, or development of engineered landfills. In order to evaluate expenditures in the long run, i.e over a period of several years during which capital equipment expenditures significantly reflect changing prices, demands and policies, information regarding plans for purchasing additional capital investments, such as the purchase of additional trucks and hiring additional full-time labour, will be required. Estimating the long-run marginal cost requires data on the per-tonne costs of not just operating and maintenance, but also data on depreciation and interest payments for the next planned stage of expansion. In the present research, data for depreciation and interest were not available from Corporation of Chennai to estimate long-run cost functions. The study was also constrained because no cost data was available from the informal sector operators in the city, which would have provided an excellent comparison of marginal costs associated with the non-formal operators in Chennai.

Currently there are no pricing studies for solid waste management in developing cities like Chennai. It is suspected though that the service quality deteriorates in developing countries because revenues allocated towards waste management are generally insufficient to cover costs, and more importantly because user-fees are set way below marginal costs. Setting user-fees based on short-run marginal costs might be beneficial for the larger sections of populations consisting of the urban poor, but it is unlikely to earn a surplus to finance improvements to service levels and expansions to serve increasing population levels. On the other hand, setting user fees based on long-run marginal costs might have the opposite effect. Future work on this topic needs to be directed towards devising a pricing structure depending on what households (both wealthy and poor) are willing to pay for different kinds of services at different costs.

6.3.2 Economy-of-scope

Economies of scope are realized through joint use of inputs, mostly sharing of fixed assets such as land, buildings, large equipment and so on. In the case of Chennai what could be evaluated is ifthere are benefits for CoC to provide waste management services in addition to providing other municipal services such as say roading or water supply. Alternatively, are there cost savings if SWM is handled by a separate organisation outside the CoC? In order to explore scope economies, data on capital and operating expenses of individual services need to be known, and also the data on shared capital assets (such as corporation building rent, and taxes and insurance for motor vehicles used by supervisory staff), along with shared operating expenses (such as common administrative staff) will be needed.

Let us assume that CoC provides two services simultaneously- roading (r) and SWM (w). Each of these services can be managed separately or jointly. Suppose that the costs for each of these services when managed separately, are C(r) and C(w),and the volume of the products are q_r(number of corporation roads serviced) and q_w(quantity of waste collected). These services individually incur capital costs F_r(e.g. for laying footpaths, drainage construction) and F_w(ex. handcarts for waste collection, trucks for transportation), and incur variable costs that depend on the volume of production αq_r(e.g. pavement and drainage repairs depending on road lengths requiring serving in Chennai) and βq_w(e.g. maintenance of handcarts and trucks depending on the quantity of waste collected). When managed separately, i.e by using separate resources for each service , the respective costs could be calculated as suggested by GermaBel's works:

Costs of roading (by CoC) : $C_r\ (q_r) = F_r + \alpha_r q_r$

Costs of SWM (by private contractor): $C_w(q_w) = F_w + \beta_w q_w$

If the two services are jointly managed, certain capital assets(such as CoC administration costs, recreational facilities for CoC staff) will be used by both services, denoted as F_{rw}. Similarly variable costs will now be determined by γ, and will change accordingly; with some costs like certain equipment that are used exclusively for each service (denoted as $\gamma_r$andγ_w), while some others such as supervisors can be used for both services . Therefore,

Costs of joint management of services: $C_{rw}(q_r,q_w) = F_{rw} + \gamma_r q_r + \gamma_w q_w + \gamma_{rw} q_r q_w$

The savings (or increase) in costs achieved by joint management of services can be expressed as follows:

Economy of scope: $Cr(_{qr})+C_w(q_w)-C_{rw}(q_{rw}) = (F_r+F_w-F_{rw}) + (\gamma_r-\alpha_r)q_r + (\gamma_w-\beta_w)q_w - \gamma_{rw}q_r q_w$

If there is positive economy of scope – that is, if $C_r(q_r)+C_w(q_w) > C_{rw}(q_{rw})$ then CoC should produce the services jointly because this strategy improves its efficiency. Otherwise it would be more cost-efficient to sub-contract the service.

Although contracting out the SWM service is being encouraged in developing countries, so far there is no empirical evidence based on costs. If basic information regarding the individual, shared capital, and operating costs are gathered for services provided by CoC, that will provide a good start to determine if contracting out SWM is more economically viable than jointly providing the service along with other services. Using the economy-of scope technique to develop management models for municipal services is a potential topic for future research.

6.3.3 Size of service provider and costs

The third type of cost analysis suggested in Chapter 5 was to study the relationship between the size of service provider and costs. A direct relationship cannot be established as there can be a number of underlying factors affecting the relationship. However, analogous to the healthcare service, one good proxy indicator suggested in Chapter 5 for SWM was the variety of waste handled. It was hypothesised that larger service providers handle more complex waste types. For example, out of the total waste generated, the CoC (which is the largest service provider in Chennai) handles approximately 68 % residential waste, 16 % commercial waste, 14 %institutional waste and 2 % industrial waste. On the other hand, the private contractor (namely Onyx/ Neel Kamal) primarily handles wastes that are collected from households and street sweeping. It is very possible that, in the zones serviced by the private contractor, the waste collected from street-sweeping will contain a small percentage (say about 20%) of commercial and institutional wastes that are illegally dumped by small businesses and institutions such as schools and temples. Finally the community based organisations, known as Exnoras, mostly rehabilitate ragpickers in their neighbourhoods by organising D-T-D collection of waste from an average of 70-75 households. However, these Exnoras also significantly differ in size and scope of activities; for example, some larger Exnora groups also organise street-sweeping and composting. In order to study the relationship between size and costs of these service providers, the type of service provider (i.e whether municipal, private contractor or CBO) becomes less relevant. The types of waste managed, along with average costs from each service provider, are more important information. In Chennai's example, such data will be needed from CoC, the private contractor and from many individual Exnoras. By specifically categorising wastes as residential, commercial, institutional and industrial, dummy variables could be assigned for each waste category from a number of service providers, and used for a cost function analysis for a start. So far no cost function research has been conducted in the waste sector that investigates the effect of the service provider size on costs, hence inclusion of a variable that measures the diversity of wastes handled (to indirectly measures service provider size) could be a potential variable analysis for future cost function researchers.

6.3.4 Accounting for informal sector activities

The research carried out on the developing city of Chennai in Chapter 4 of the thesis can be extended; while that work was concentrated on the formal service providers in the city, the analysis could be repeated by collecting similar data from the informal sector (in Chennai's case, the city's informal sector mainly constituted of the community based organisations known as Exnoras, details on www.exnora.org). An analysis that includes data from both the formal service providers, and informal service providers could be performed in the following way:

Similar to Figure 4.3 in Chapter 4, build another material-cum-cost flow path model for the informal sector. The one shown in Figure 4.3 was mostly for the materials that end up in the dumpsites of Chennai. About 400 tonnes per day was estimated as being recycled, mostly informally by the CoC collection workers, and finally ending up in a market. Let us assume that x amount of waste is recycled outside the formal system by 1500 or so Exnoras in

Chennai. Exnoras employ waste pickers for collecting waste from their neighbourhoods. Similar to the CoC analysis, first activities and associated costs need to be laid out for Exnora's recycling system.

Based on general literature on informal recycling in developing cities, let us assume that the activities performed by Exnoras are collection, processing and reprocessing of waste.

Collection: Assume that collection costs of recycling by Exnoras comprise the expenses incurred for: 1. Labour costs for door-to-door collection of mixed waste, 2. Labour costs for transporting recovered material to the recyclables market, and 3. capital costs for items such as collection vehicles and containers, and smaller items such as brooms etc. In case itinerant waste buyers are also involved in collecting recyclables from households in exchange for money or finished materials, they also become waste collectors. Hence total collection cost is the sum of operating expenses of waste pickers and itinerant waste buyers to collect and transport waste, and the depreciation on the capital cost of collection. Being a labour intensive activity with little or no financial support from CoC, it is highly likely that capital costs of Exnoras are insignificant in collection of recyclables.

Processing : The next common activity would involve the 'processing' of recyclables; operations under this activity would mostly be performed manually and would commonly include (a) sorting and separation of the recovered mixture into individual materials such as glass, plastic and metals, (b) removing contaminants and (c) packing for transportation to reprocessing industries. This activity might either be performed directly by Exnora's waste collectors who sell the sorted recyclables, or may involve wholesale dealers who employ cheap labour to carry out the operations listed. There may also be some additional expenditures on building rent, power for wholesale dealers, along with wages for labour employed.

Reprocessing: The final activity of converting recyclables to recycled material will be done in a re-processing industry in Chennai, and would not be part of Exnora's activities. However, the market price offered by that reprocessing industry will have an inverse relationship with the degree of separation at the collection and sorting stage.

Informal recycling in developing countries is known to be a revenue- incurring process with little expenditures involved when compared to the formal sector such as the CoC in Chennai. Similar to development of cost functions (which in reality are expenditure functions) in this thesis, associated with informal recycling activities suggested above, these would be revenue-incurring activities determined by the market price for recyclables at each stage of the activity. Hence, the revenues earned at each stage of activities listed above will need to be determined.

The above was a hypothetical example based on general literature on informal recycling in developing cities. The example was intended to point to the sort of data that need to be collected in order to include the informal sector when developing cost functions. Apart from the suggested direction here, there are other interrelated factors such as avoided disposal costs to the formal sector, reduction of street-litter, employment of the poor, which need to be explored in a future analysis when including the informal sector.

6.3.5 Input prices

It was shown in Chapter 5 that factor prices for inputs such as labour and capital are particularly important when formulating cost functions. In the study of Chennai city in Chapter 4, recall that two scenarios were investigated. Under scenario 1, namely 'growth within city' scenario, the effect of input prices were not necessary to be incorporated since it was assumed that input prices were uniform throughout Chennai's urban areas, and not changing over the (short) period of expansion. In the second scenario, namely 'expansion of city bounds' scenario,in which CoC expands its current operations to 14 Municipalities, 20 Town Panchayats and 21 Village Panchayats around Chennai City, the effects of input prices will have had an effect on costs. This is because the input prices that these less urban municipalities, and more rural town and village panchayats incur will be lower than the labour and depreciation rates for CoC services. Data on input prices were unavailable from municipalities, and village and town panchayats, which was a limitation while exploring scenario 2 in the Chennai study. An option that could be explored in future research would be to incorporate dummy variables for different types or urbanisation levels.

6.3.6 Type of ownership and costs

Development of activity-wise cost functions using cost per tonne data from a range of service providers would be the ideal way to explore the issue of which type of ownership costs less for a particular solid waste management activity. To answer this question for Chennai, a comparison of collection costs between CoC, the private contractor (Onyx/ Neal Metal) and Exnoras will be needed. Collection of wastes from households is the only common activity performed by these service providers. Other activities should not be included as that would not allow for a fair comparison. This would in turn prevent over-lapping of services in certain areas and also create a positive environment for multiple service provides to operate alongside each other to avoid conflicts. For example, in Chennai, this could mean that Exnoras could be responsible for primary collection, the private contractor for transfer and transport, and CoC could focus solely on engineered disposal.

In summary, a solid waste management cost function should be specified as below:

$$C = f\,(Q, T, A, P, I, O)$$

where C= Cost per tonne or Cost per tonne of each service provider

Q= quantity of wastes managed in tonnes

T = (diversity of) solid waste types (e.g. % residential, % commercial etc.)

A= (diversity of) solid waste management activities (e.g. develop activity-wise cost functions)

P = Input prices for labour, capital and fuel

I = Informal sector involvement (by proportion, as an independent variable, or through dummy variables)

O = Type of ownership (e.g by using dummy variables for municipal, private contractor, NGO, CBO, independent wastepickers)

6.4 Constraints, challenges and limitations

Collecting detailed information, which is paramount for performing a cost function analysis, was one of the biggest constraints on this research. The value in conducting cost function analysis demonstrated through this research is expected to provide some motivation for service providers in developing countries to share and improve the data accounted, at least for research purposes for a start. During the field visit to Indian cities, it was noticed that most service providers were enthusiastic about sharing their experiences during informal one-on-one discussions. It was learnt that most cost decisions in the waste sector in India are currently based on heuristic thinking, engineering judgements or historical thumbrules.

As a result, future researchers on this topic need to be aware that data, particularly cost data, needed for this type of research are not readily available and are challenging to collect. Future researchers might benefit from starting out with questionnaires containing research questions while seeking the specific data for answering them. A sample questionnaire based on the research findings from this thesis is provided in Table 6.2. The proposed questionnaire is very detailed and is intended to be a prototype to collect all the data needed to perform all the cost function analyses listed in Chapter 5 of this thesis. Future researchers may wish to seek only those data needed to answer one or more of the research questions listed in section 5.2.2 of this thesis. For example, if the intention of conducting cost function analysis is to investigate whether economy of scope exists through joint use of inputs for a particular municipality, the data that needs to be sought are the ones listed in 1 to 4, and 7 (a,b,c) of Table 6.2.

Chapter 5 of this thesis will be helpful in formulating research questions and collecting necessary data. Doing so will provide a better understanding for service providers to gather necessary information from their sources that is required for the research. Also, based on their own experience, service providers may even provide suggestions for other types of useful data that might be more readily available.

Next, for a better understanding of the system that is being analysed, questionnaires can be supplemented with accounting data, where available from the service provider. These would typically contain waste quantities recorded by weighbridges at dumpsites and total expenditures incurred (either actual/budgeted). . Chalking out a process flow diagram of the system being analysed is also useful, particularly for a cost analysis, as it specifically lays out cost-incurring activities. An example of the usefulness of a process flow diagram (containing activities, costs and material flow), was shown in Chapter 4 , when trying to understand the system under which CoC operates in Chennai. That work was restricted to the formal service providers in Chennai. For a complete system analysis for Chennai, similar information on activities, costs (expenditures and more importantly revenues) and material flow from the various Exnoras in Chennai will be needed, and the analysis done in Chapter 4 can be repeated.

Table 6.2: Solid Waste Management (SWM) Cost Function Research Questionnaire

This questionnaire has been prepared by ____ in the year ____with the purpose of streamlining the collection of data and information for development of cost functions.

Any additional information, and/or your personal contacts with expertise in SWM from your organisation who would share their experiences, will be most appreciated.

Table starts on the next even-numbered page

	Population served (in millions)	Area covered (m^2)
1.Name of region:		
Total Urban		
Total Rural		
2.Sub-divisions, if any municipalities/districts/zones		
1.		
2. add more rows if needed		

3.Name of Currency*-	Exchange to USD			
* Please inform whether the exchange rate is end-of-financial year or average.	2010	2011	2012	2013

4.Type of service provider in sub-division (tick one or more)	Local government	Private Contractor	NGO	CBO	Independent waste pickers/IWBs
a.					
b. (add more rows if needed)					

5.Breakdown of activities of each service provider (add more columns if required)
(Q=approx. quantity of waste managed; E= expenditure incurred in carrying out the activity)

Type of provider	Collection from community bins (Q= ; E =)	Door to door collection (Q= ; E =)	Street sweeping (Q= ; E =)	Transport to transfer station (Q= ; E =)	Trans port to dum psite (Q= ; E =)
Local government					
Private Contractor					
NGO					
CBO					
Independent waste pickers/IWBs					

6.Total waste generated (in tonnes per year) =					
% generated by each service user and (add user fees paid in brackets, if	Residential	Commerci al	Institution al	Industrial	Others (add more columns if needed)

any)					

7.Cost data			
a. List capital assets owned by service provider (vehicles, equipment, land, buildings, others?)			
Name	Lifetimes	Depreciation	Repair and Maintenance
1.			
2.			
add more rows, if needed			

b. Labour costs	Full-time employees	Part-time employees	Casual labour
Monthly Salaries			
Other benefits, if any			
Other costs			
Fuel			
Central administration			
Public awareness campaigns			
Add rows as needed			

c. Costs of shared capital and labour with other municipal services		
List of other services	Shared capital with SWM	Shared labour and other operating costs
1.		
2.		
3. (add more rows if needed)		
Cost of individual services	Capital expenditure	Operating expenditure
Service 1		
Service 2		
Service 3		

d. Details of investment projects	Start year:	Expected finish date:
Project name:		
Project description:		

e. List additional capital and operating items purchased/due for purchase	1. 2. 3.
f. Additional expenditure expected in the next__ years (item-wise preferred)	

Data collected from developing countries are likely to cause serious limitations in research results, if not carefully planned for during the data collection stage. Here are a few pointers for future cost function researchers that might be useful while collecting data:

- When planning improvements for a developing region's overall SWM system, make enquiries about the presence of the non-formal organisations that operate alongside and independently of the city's municipality. The population and area data that most likely will be obtained from census reports needs to be adjusted to the proportion that the service provider in question is servicing.

- If analysing SWM data of a particular service provider, seek information about capital (equipment), lifetimes and depreciation rates. Most accounting data contain data pertaining to operating costs only.

- Factor prices of capital and labour are important when developing long-run cost functions and need to be pursued for a quality analysis.

6.5 Specific contributions of this thesis

In summary, this research makes six contributions toward the goal of improving cost estimation for SWM in developing countries. First, the importance of using the correct cost estimation method for planning improvements to SWM systems has been identified. Second, the potential application of the cost function method to a developing country dataset has been demonstrated and challenges presented. Third, the proper use of cost yardsticks in SWM and the value of using them for comparative analyses is highlighted. Fourth, the concept of marginal cost is introduced. It is shown that estimating marginal costs is an improvement over using average or recurrent costs that are normally used for budgeting purposes in developing countries. Estimating marginal costs is also useful for setting appropriate user fee rates to improve finances for the service in developing countries. Marginal cost estimation is just one of the results of cost function analyses. The fifth contribution of this thesis is in introducing to civil engineers other cost functions analyses that are more commonly performed by economists. In order to progress forward and improve planning of this very important engineering service, the advice provided in Chapter 5 of the thesis will facilitate civil engineers venturing into the topic of cost economics for SWM. The final contribution is in showing how the lessons from the healthcare study could be applied to a developing city like Chennai, the specific data needed to move forward on this topic, and what in turn that implies about the need for further work.

The systems for managing waste in a developing country are complex mainly because of the inter-relationships between a large number of stakeholders. This is one common but varying factor between different transitional economies. The work done in this thesis is based on the background knowledge of waste systems in the Indian sub-continent. The method developed here can be applied and refined using data from other developing countries facing similar waste challenges.

6.6 A note to other stakeholders on how this work be used and improved

Other stakeholders, such as urban planners, economists, and also engineers working in other fields of engineering services such as water supply and wastewater treatment, might like to note that the methodology of estimating cost functions as shown in this thesis can potentially be applied as an advanced cost estimation technique for projects requiring expansion or improvements to service levels. For example, similar to SWM, water and wastewater service providers also cater to different consumers such as households, institutions, commercial businesses and industries. Revenues and expenditures on these other municipal services also come from public taxes, loans and grants. As pointed out in Chapter 5 of this thesis, developing countries problems for other municipal services are similar. For example, user charges for water and wastewater are currently unable to financially sustain the service, similar to SWM, hence research in estimating marginal costs would be extremely beneficial even there.

The scenario analysis conducted for Chennai in Chapter 4 will be useful to urban planners in large developing cities when planning future infrastructure projects. For example, the two scenarios analysed in that chapter can be applied when investigating the future development of, say, transportation network expansions in mega-cities. In summary, the work conducted in this thesis is to provide not just engineers, but all those involved in the management of public services, an opportunity to move away from traditional cost estimation methods that are currently inefficient in handling urban challenges in developing countries, and instead provide a rational basis for making cost-wise decisions in their field of work.

APPENDIX A: PHOTOGRAPHS TAKEN DURING A FIELD VISIT TO INDIAN CITIES IN 2010

Figure A.1: Waste collection: door to door
(Location: Bangalore, India; Photo: Shantha Parthan)

Figure A. 2: Waste collection: street sweeping
(Location: Bangalore, India; Photo: Shantha Parthan)

Figure A.3: Waste collection: neighbourhood community bin
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A. 4: Secondary storage and transfer site
(Location: Bangalore, India; Photo: Shantha Parthan)

Figure A. 5: Transfer station: unloading wastes from a smaller vehicle to a larger one
(Source: Undisclosed)

Figure A. 6: Transport to dumpsite- wastes from secondary storage point to unload at dumpsite (Location: Bangalore, India; Photo: Shantha Parthan)

Figure A.7: Transport to dumpsite: community bin lifted and unloaded at dumpsite (Location: Delhi, India; Photo: Shantha Parthan)

Figure A.8: Unloading at dumpsite
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.9: Informal sector: independent waste picker
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.10: Informal sector: family of waste pickers
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.11: Informal sector: independent waste recycler
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.12: Informal sector: itinerant waste buyers
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.13: Open dump site
(Location: Delhi, India; Photo: Shantha Parthan)

Figure A.14: 'Garbage Mountain' at Delhi's dumpsite
(Photo: Shantha Parthan)

APPENDIX B: SUPPLEMENTARY DATA FOR CHAPTER 3

* The complete NIUA dataset is available as an addendum from Page 250 of this thesis. This data is downloadable from

http://www.urbanindia.nic.in/theministry/statutorynautonomous/niua/swm.pdf

Table B.1: Basic statistics of variables used in analysis

(See note at end of table for explanation of column headings)

Metropolitan cities		Y		x_1		x_2		x_3		x_4		x_5		x_6		x_7		x_8	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
N		21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Mean		2.63	15.68	15.23	15.23	6.59	6.59	0.051	0.118	4.45	4.45	2.05	0.0129	0.14	0.14	0.57	0.57	0.71	0.71
Std Deviation		1.93	10.33	7.10	7.10	3.79	3.79	0.022	0.041	3.12	3.12	0.97	0.0053	0.36	0.35	0.51	0.51	0.46	0.46
Percentiles	10	0.24	2.50	6.22	6.22	2.19	2.19	0.027	0.057	2.00	2.00	0.71	0.0059	0	0	0	0	0	0
	90	5.13	34.23	25.03	25.03	13.21	13.20	0.092	0.177	8.00	8.00	3.59	0.0201	1	1	1	1	1	1
Class I cities																			
N		150	149	123	122	123	122	149	148	149	149	147	146	147	146	150	149	150	149
Mean		1.93	20.46	10.23	10.23	3.14	3.16	0.081	0.303	5.28	5.28	1.84	7.165	0.44	0.45	0.25	0.25	0.19	0.19
Std Deviation		1.42	15.88	5.11	5.11	2.79	2.79	0.176	0.678	2.22	2.22	0.85	6.290	0.50	0.49	0.43	0.43	0.40	0.39

Percentiles	10	0.57	4.67	4.65	4.65	0.70	0.69	0.024	0.079	2.00	2.00	0.82	3.331	0	0	0	0	0	0
	90	3.09	36.52	17.45	17.46	7.21	7.28	0.126	0.561	8.00	8.00	2.91	15.100	1	1	1	1	1	1
Class II towns																			
N		98	99	96	97	96	97	98	99	97	98	97	98	98	99	98	99	98	99
Mean		1.88	29.50	9.18	9.18	2.01	2.03	0.076	0.48	4.45	4.45	1.86	11.002	0.57	0.60	0.13	0.13	0.18	0.18
Std Deviation		1.53	26.67	7.81	7.81	2.00	2.00	0.082	0.71	3.39	3.39	0.90	9.321	0.89	0.91	0.34	0.34	0.38	0.39
Percentiles	10	0.34	5.35	3.02	3.02	0.45	0.45	0.020	0.10	2.00	2.00	0.89	3.159	0	0	0	0	0	0
	90	2.92	65.84	19.97	19.97	3.96	4.08	0.191	1.28	7.00	7.00	3.15	24.006	1	1	1	1	1	1
All data included																			
N		269	269	240	240	240	240	268	268	267	268	265	265	266	266	269	269	269	269
Mean		1.96	23.41	10.27	10.27	2.99	3.00	0.077	0.35	4.08	4.08	1.860	8.111	0.47	0.48	0.23	0.23	0.23	0.23
Std Deviation		1.51	20.75	7.41	7.41	2.88	2.87	0.140	0.67	3.10	3.10	0.876	8.000	0.66	0.68	0.42	0.42	0.42	0.42
Percentiles	10	0.43	4.70	3.23	3.23	0.599	0.599	0.022	0.08	2.00	2.00	0.822	0.752	0	0	0	0	0	0

	90	3.19	47.99	20	20	7.33	7.33	0.143	0.64	8.00	8.00	3.082	18.364	1	1	1	1	1	1

Notes:

Dependent variable (y) and Independent variables (x_s); (1)= per person analysis (2)= per tonne analysis	Metropolitan Cities (population >1,000,000) Class I cities (100,000 to 1,000,000) Class II cities (50,000 to 100,000) All data (combined data of the 3 population ranges above)	y = cost in USD per person in (1) and per tonne in (2) x_1=population density in 1000s of persons km^{-2} x_2=waste per unit area in tonnes km^{-2} x_3= No. of vehicles used for transportation per person in (1) and per tonne in (2) x_4= average trips vehicle^{-1} day^{-1} x_5=Total no. of staff employed per person in (1) and per tonne in (2) x_6=Frequency of collection (0=once daily; 1= More than once) x_7=Is some aspect privatized (0-NO; 1-YES) x_8= Medical waste collected and disposed separately?? (0-NO; 1-YES)

Table B.2: Number of outliers removed out of total number of data points used in analysis

Population Range	**CPC**	**CPT**
Metropolitan Cities (population >1,000,000)	0 out of 21	0 out of 21
Class I cities (100,000 to 1,000,000)	3 out of 150	4 out of 149
Class II cities (50,000 to 100,000)	3 out of 98	3 out of 99
All data included	7 out of 269	10 out of 269

Table B. 3(a) Significant Variables and Regression Coefficients of CPC analysis

Significant Variables	Coefficients (standard error)	Standardized Coefficients	Significance
Metropolitan Cities			
(Constant)	-1.8 (.85)		0.053
x_5=Total no. of staff employed per capita	1.1600 (.290)	.58	0.001
x_3= No. of vehicles used for transportation per 1000 people	39.623 (12.530)	.46	0.005
Class I cities			
(Constant)	.88. (184)		<0.001
x_5=Total no. of staff employed per capita	0.470 (0.080)	.47	<0.001
x_7=Is some aspect privatized?	-.37 (.17)	-.18	0.027
x_6=Frequency of collection	.029 (0.14)	.17	0.027

Class II cities			
(Constant)	.74 (0.184)	.527	<0.001
x_5=Total no. of staff employed per capita	525 (0.091)		<0.001
All data included (without population classifications)			
(Constant)	.662 (0.128)	.466	<0.001
x_5=Total no. of staff employed per 1000 people	.491 (0.060)		<0.001
x_2=WPA (tonnes km $^{-2}$)	.071 (0.019)	.215	<0.001

Table B.3 (b) Significant Variables and Regression Coefficients of CPT analysis

Significant Variables	Coefficients (standard error)	Standardized Coefficients	Significance
Metropolitan Cities			
(Constant)	4.6 (5.505)		0.416
x5=Total no. of staff employed per tonne	858 (394.27)	.45	0.042
Class I cities			
(Constant)	7.034 (1.163)		<0.001
x5=Total no. of staff employed per tonne	1.829 (0.120)	.803	<0.001
x7= Is some aspect privatized?	-4.248 (1.563)	-0.143	<0.001

Class II cities			
(Constant)	-3.0 (2.441)		0.220
x5=Total no. of staff employed per tonne	2.08 (0.143)	0.78	<0.001
x1=population density	.00087 (0.00016)	0.29	<0.001
All data included (without population classifications)			
(Constant)	7.458	0.819	<0.001
x5=Total no. of staff employed per tonne	1.786		<0.001

APPENDIX C: SUPPLEMENTARY DATA FOR CHAPTER 4

Table C.1 : Expenditure on Primary waste collection

(Source: CoC)

SOLID WASTE MANAGEMENT

SWEEPING AND COLLECTION OF GARBAGE (EXPENDITURE STATEMENT)

RUN DATE: 05.03.2009

PARTICULARS	DESCRIPTION	ACTUALS												R.E.
		1996-97	1997-98	1998-99	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
		(RUPEES IN LAKH)												
A. OPERATING &	a) Solid Waste Management (Zones)	45.31	0.04	48.29	58.03	45.79	885.71	3583.63	3707.76	4536.18	4599.56	4478.26	4195.37	4178.75
MAINTENANCE COST	b) Bullock Carts (Zones)	12.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.02
1. Operating Expenses	TOTAL - OPERATING EXPENSES	**57.56**	**0.04**	**48.29**	**58.03**	**45.79**	**885.71**	**3583.63**	**3707.76**	**4536.18**	**4599.56**	**4478.26**	**4195.37**	**4178.77**
2. Repairs & Maintenance	a) Solid Waste Management (Zones)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	24.33	16.54	29.95	43.77	47.12
Expenses	b) Bullock Carts (Zones)	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	TOTAL - REPAIRS & MAINTENANCE EXPENSES	**0.55**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.30**	**24.33**	**16.54**	**29.95**	**43.77**	**47.13**
GRAND TOTAL (OPERATING & MAINTENANCE COST - "A")		**58.11**	**0.04**	**48.29**	**58.03**	**45.79**	**885.71**	**3583.63**	**3708.06**	**4560.51**	**4616.10**	**4508.21**	**4239.14**	**4225.90**
B. PERSONNEL COST	a) Solid Waste Management (Zones)	2923.62	3618.36	4731.86	5291.99	5412.00	5079.85	5175.35	5250.80	5490.69	6112.38	7407.54	7744.88	12151.69
1. Personnel Cost	b) Bullock Carts (Zones)	272.42	239.67	185.01	194.90	29.30	9.85	9.82	10.40	10.85	10.89	12.76	15.16	26.48
	TOTAL - PERSONNEL COST - "B"	**3196.04**	**3858.03**	**4916.87**	**5486.89**	**5441.30**	**5089.70**	**5185.17**	**5261.20**	**5501.54**	**6123.27**	**7420.30**	**7760.04**	**12178.17**
C. ADMINISTRATION COST	a) Solid Waste Management (Zones)	79.36	238.02	379.42	282.41	64.09	14.78	62.65	33.16	95.43	45.63	42.61	97.34	189.41
1. Administration Expenses	b) Bullock Carts (Zones)	1.45	0.97	1.33	1.71	0.87	0.35	0.28	0.36	0.51	0.25	0.09	0.08	0.20
	TOTAL - ADMINISTRATION COST - "C"	**80.81**	**238.99**	**380.75**	**284.12**	**64.96**	**15.13**	**62.93**	**33.52**	**95.94**	**45.88**	**42.70**	**97.42**	**189.61**
	TOTAL SERVICE COST - "A+B+C"	**3334.96**	**4097.06**	**5345.91**	**5829.04**	**5552.05**	**5990.54**	**8831.73**	**9002.78**	**10157.99**	**10785.25**	**11971.21**	**12096.60**	**16593.68**

TableC.2 : Expenditure on transportation

(Source: CoC)

SOLID WASTE MANAGEMENT

GARBAGE TRANSPORTATION EXPENDITURE STATEMENT

RUN DATE: 05.03.2009

PARTICULARS	DESCRIPTION	ACTUALS												R.E.
		1996-97	1997-98	1998-99	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
		(RUPEES IN LAKH)												
A. OPERATING & MAINTENANCE COST	a) Transport Station (M.E. Department)													
	i) 'B' Depot	105.06	124.85	167.15	165.40	290.12	280.46	238.41	277.46	322.52	396.31	477.75	502.10	671.00
1. Operating Expenses	ii) 'D' Depot	193.26	247.81	220.84	275.36	301.83	286.38	387.27	508.95	654.27	797.42	951.01	965.79	1238.00
	b) Vehicle Maintenance (Zones)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL - OPERATING EXPENSES	**298.32**	**372.66**	**387.99**	**440.76**	**591.95**	**566.84**	**625.68**	**786.41**	**976.79**	**1193.73**	**1428.76**	**1467.89**	**1909.00**
2. Repairs & Maintenance Expenses	a) Transport Station (M.E. Department)													
	i) 'B' Depot	130.15	186.40	247.09	235.56	238.83	181.31	176.17	275.38	239.56	301.99	317.52	374.57	445.02
	ii) 'D' Depot	150.20	202.19	184.69	244.70	246.92	207.35	183.94	285.68	269.57	359.20	387.09	472.84	495.02
	b) Vehicle Maintenance (Zones)	1.11	2.12	1.94	0.96	0.76	0.56	0.90	0.87	0.74	0.46	0.35	0.14	0.45
	TOTAL - REPAIRS & MAINTENANCE EXPENSES	**281.46**	**390.71**	**433.72**	**481.22**	**486.51**	**389.22**	**361.01**	**561.93**	**509.87**	**661.65**	**704.96**	**847.55**	**940.49**
GRAND TOTAL	(OPERATING & MAINTENANCE COST - "A")	**579.78**	**763.37**	**821.71**	**921.98**	**1078.46**	**956.06**	**986.69**	**1348.34**	**1486.66**	**1855.38**	**2133.72**	**2315.44**	**2849.49**
B. PERSONNEL COST	a) Transport Station (M.E. Department)													
1.Personnel Cost	i) 'B' Depot	84.87	103.27	134.54	143.94	135.97	125.12	125.27	130.49	134.41	141.40	166.99	180.67	260.43
	ii) 'D' Depot	119.56	129.05	170.77	177.10	177.42	168.10	171.04	171.15	181.93	187.08	221.97	230.08	335.02
	b) Vehicle Maintenance (Zones)	395.05	464.32	624.68	760.52	806.07	804.43	808.44	831.80	885.71	955.25	1136.45	1222.47	1666.56
	TOTAL - PERSONNEL COST - "B"	**599.48**	**696.64**	**929.99**	**1081.56**	**1119.46**	**1097.65**	**1104.75**	**1133.44**	**1202.05**	**1283.73**	**1525.41**	**1633.22**	**2262.01**
C. ADMINISTRATION COST	a) Transport Station (M.E. Department)													
	i) 'B' Depot	19.72	21.58	29.74	34.28	38.87	31.72	45.38	87.94	76.67	86.75	103.97	146.57	284.51
1.Administration Expenses	ii) 'D' Depot	22.85	29.16	37.31	38.53	32.27	30.41	32.44	64.72	58.29	61.83	91.96	145.14	213.26
	b) Vehicle Maintenance (Zones)	0.87	0.10	0.08	0.06	0.00	0.01	0.08	2.42	0.96	1.92	1.23	1.53	2.23
	TOTAL - ADMINISTRATION COST - "C"	**43.44**	**50.84**	**67.13**	**72.87**	**71.14**	**62.14**	**77.90**	**155.08**	**135.92**	**150.50**	**197.16**	**293.24**	**500.00**
	TOTAL SERVICE COST - "A+B+C"	**1222.70**	**1510.85**	**1818.83**	**2076.41**	**2269.06**	**2115.85**	**2169.34**	**2636.86**	**2824.63**	**3289.61**	**3856.29**	**4241.90**	**5611.50**

Table C.3 : Item-wise expenditure

(Source: CoC)

பிரிவின் செலவு விவரங்கள்
COST CENTREWISE EXPENSES BUDGET SUMMARY

Form No. C 1

துறை : மண்டல அலுவலகம் 1
Department : Zonal Office - I (F.A.)

பிரிவு : திடக் கழிவு மேலாண்மை
Cost Centre : Solid Waste Management (33)

கணக்கு எண் Account Code	கணக்கு தலைப்பு Account Head	பார்வை Ref.	கணக்குகள் 2007-2008 Actuals 2007-2008	வரவு செலவு திட்ட மதிப்பீடு 2008-2009 Budget Estimate 2008-2009	திருத்திய திட்ட மதிப்பீடு 2008-2009 Revised Estimate 2008-2009	வரவு செலவு திட்ட மதிப்பீடு 2009-2010 Budget Estimate 2009-2010
				(ரூபாய் ஆயிரத்தில்) (Rupees in Thousand)		
100-159	பணியாளர் செலவு Personnel cost	C2	7,81,61	10,57,21	11,01,26	15,16,86
160-199	இயக்க செலவுகள் Operating Expenses	C3	16,07	50	10	10
200-249	பழுதுபார்த்தல் மற்றும் பராமரிப்பு Repairs and Maintenance	C4	3,46	3,01	8,01	5,01
330-369	நிர்வாக செலவுகள் Administration Expenses	C7	40	35	14,50	6,30
		மொத்தம் Total	8,01,54	10,61,07	11,23,87	15,28,27

பணியாளர் செலவுத் திட்டம்
PERSONNEL COST BUDGET

Form No. C 2

100	சம்பளம் Salaries		36,62	51,00	38,00	52,60
101	ஈட்டிய விடுப்பு சம்பளம் Leave Salary Surrender		34,56	35,00	35,00	40,00
104	ஊதியம் பிற இனத்தவர் Wages-Others		6,49,16	9,00,00	9,95,00	13,92,00
		மொத்தம் Sub-Total-A	7,20,34	9,86,00	10,68,00	14,84,60
110	மருந்து செலவிற்கு ஈடு செய்தல் Reimbursement of Medical Expenses		-	1	1	1
111	நலவசதி செலவுகள் Welfare Expenses		18	1,85	2,00	2,00
113	சீருடை Uniform		-	3,00	9,00	5,00
116	நிரந்தரமற்ற பணியாளர் ஊதியம் Payment to Casual Staff		61,04	66,00	22,00	25,00
119	பயணச் சலுகை Travel Concession		-	5	5	5
121	மருத்துவமனைகளில் மருத்துவச் செலவு Hospitalisation Benefits		5	30	20	20
		மொத்தம் Sub-Total-B	61,27	71,21	33,26	32,26
		மொத்தம் Total A+B	7,81,61	10,57,21	11,01,26	15,16,86

இயக்க செலவுகள் திட்டம்
OPERATING EXPENSES BUDGET

Form No. C 3

துறை : மண்டல அலுவலகம் 1
Department : Zonal Office - I (F.A.)

கணக்கு எண் Account Code	கணக்கு தலைப்பு Account Head	பார்வை Ref.	கணக்குகள் 2007-2008 Actuals 2007-2008	வரவு செலவு திட்ட மதிப்பீடு 2008-2009 Budget Estimate 2008-2009	திருத்திய திட்ட மதிப்பீடு 2008-2009 Revised Estimate 2008-2009	வரவு செலவு திட்ட மதிப்பீடு 2009-2010 Budget Estimate 2009-2010
				(ரூபாய் ஆயிரத்தில்) (Rupees in Thousand)		
163	பண்டக பொருட்கள் Stores Consumption		16,07	50	10	10

பழுதுபார்த்தல் மற்றும் பராமரிப்பு திட்டம்
REPAIRS AND MAINTENANCE BUDGET

Form No. C 4

211	கனரக வாகனங்கள் பழுதுபார்க்கும் செலவு Heavy Vehicles out side Repair Charges		3,46	3,00	8,00	5,00
249	உரத் தொட்டிகள் Compost Bins		-	1	1	1
		மொத்தம் Total	3,46	3,01	8,01	5,01

நிர்வாக செலவுகள் திட்டம்
ADMINISTRATION EXPENSES BUDGET

Form No. C 7

334	தொலைபேசி செலவு Telephone Charges		4	10	10	10
339	மின்சார செலவு Electricity Charges		13	20	20	20
360	வாகன கட்டணம் Hire Charges		-	-	10,00	5,00
369	பல்வகை செலவுகள் Miscellaneous Expenses		23	5	4,20	1,00
		மொத்தம் Total	40	35	14,50	6,30

Items in Table C.4:

1- Ward number

2- Population as per 2001 census

3- Predicted population in 2006 (applying a 3.95% increase per year)*

4- Number of sanitation workers = Col.3/1000

5- Number of supervisors = Col.4 /25

6- Cost of labour in Indian Rupees*= ((Col.4)*6000*12)+((Col.5)*4500*12)

7- Number of handcarts and tricycles required (useful life of 3 years)= Col. 4

8- O&M costin Indian Rupees =1500* Col. 7

9- Road lengths in high density areas = (Total road length in kilometres of bus routes per zone /total number of wards per zone)*1000

10- Road lengths in medium density areas = (Total road length in kilometres of interior roads per zone /total number of wards per zone)*1000

11- No. of street sweepers required for sweeping high density areas = Col.9/ 250

12- No. of street sweepers required for sweeping medium density areas = Col.10/ 400

13- Number of street sweepers needed = Col. 11+ Col.12

14- Cost of labour for street sweeping in Indian Rupees = Col.13 * 6000

15- Number of handcarts/wheelbarrows required = Col. 13

16- O&M cost in Indian Rupees =1500* Col. 15

17-Number of transport vehicles needed= (Col.2/5000*)/10

18- Number of transport vehicle drivers required= Col.17 * 2

19- Cost of labour to drive transport vehicles in Indian Rupees = Col. 18 * 6000 *12

* 1USD= 45 Indian Rupees in 2006

Table C.4: Total predicted cost calculations using yardsticks for Chennai data

	POPULATION		D-T-D COLLECTION					STREET SWEEPING								TRANSPORTATION		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	57723	70060	70	3	5195664	70	105090.30	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	3	201773
2	50385	61154	61	2	4535169	61	91730.76	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	2	176123
3	43112	52326	52	2	3880524	52	78489.56	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	2	150700
4	20961	25441	25	1	1886706	25	38161.53	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	1	73270
5	38446	46663	47	2	3460536	47	69994.66	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	2	134390
6	22210	26957	27	1	1999129	27	40435.45	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	1	77636
7	21720	26362	26	1	1955024	26	39543.36	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	1	75923
8	31558	38303	38	2	2840545	38	57454.39	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	2	110312
9	19301	23426	23	1	1737289	23	35139.33	1993.08	19583.08	8	49	57	4098960.00	57	1500	0	1	67468
10	38511	46742	47	2	3466387	47	70113.00	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	2	134617
11	28146	34162	34	1	2533430	34	51242.51	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	1	98386
12	17071	20720	21	1	1536566	21	31079.40	1993.08	19583.08	8	49	57	4098960.00	57	1500	0	1	59672
13	21192	25721	26	1	1907498	26	38582.08	1993.08	19583.08	8	49	57	4098960.00	57	1500	1	1	74078
14	32373	39292	39	2	2913903	39	58938.17	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	2	113161
15	21589	26203	26	1	1943232	26	39304.86	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	75465
16	23959	29080	29	1	2156557	29	43619.67	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	83750
17	24152	29314	29	1	2173929	29	43971.05	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	84424
18	15719	19079	19	1	1414872	19	28617.96	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	54946
19	17174	20845	21	1	1545837	21	31266.93	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	60032
20	16921	20538	21	1	1523064	21	30806.32	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	59148
21	19681	23887	24	1	1771493	24	35831.16	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	68796
22	27698	33618	34	1	2493105	34	50426.88	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	96820
23	16510	20039	20	1	1486070	20	30058.05	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	57711
24	17326	21029	21	1	1559518	21	31543.66	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	60564
25	17669	21445	21	1	1590392	21	32168.12	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	61763
26	22797	27669	28	1	2051965	28	41504.14	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	79688
27	17999	21846	22	1	1620095	22	32768.92	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	62916
28	24788	30086	30	1	2231175	30	45128.95	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	86648
29	16769	20353	20	1	1509383	20	30529.58	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	58617
30	16718	20291	20	1	1504792	20	30436.73	1044.44	6798.89	4	17	21	1524600.00	21	1500	0	1	58439
31	25845	31369	31	1	2326316	31	47053.32	1044.44	6798.89	4	17	21	1524600.00	21	1500	1	1	90342
32	37155	45096	45	2	3344333	45	67644.27	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	129877
33	34667	42076	42	2	3120387	42	63114.62	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	121180
34	38650	46911	47	2	3478898	47	70366.06	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	135103
35	26359	31993	32	1	2372581	32	47989.11	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	1	92139
36	39649	48123	48	2	3568818	48	72184.83	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	138595
37	22692	27542	28	1	2042514	28	41312.98	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	1	79321

38	36038	43740	44	2	3243791	44	65610.66	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	125972
39	30533	37059	37	1	2748284	37	55588.28	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	1	106729
40	41934	50897	51	2	3774492	51	76344.90	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	2	146582
41	18632	22614	23	1	1677072	23	33921.36	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	65129
42	24145	29306	29	1	2173299	29	43958.30	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	1	84400
43	13469	16348	16	1	1212349	16	24521.62	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	47082
44	13642	16558	17	1	1227920	17	24836.58	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	47686
45	20101	24397	24	1	1809297	24	36595.81	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	70264
46	11970	14528	15	1	1077423	15	21792.54	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	41842
47	12308	14939	15	1	1107847	15	22407.90	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	43023
48	22615	27449	27	1	2035583	27	41172.79	1395.56	12328.33	6	31	36	2621020.00	36	1500	1	1	79052
49	15004	18211	18	1	1350514	18	27316.23	1395.56	12328.33	6	31	36	2621020.00	36	1500	0	1	52447
50	43398	52674	53	2	3906267	53	79010.25	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	2	151700
51	44279	53743	54	2	3985566	54	80614.20	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	2	154779
52	21284	25833	26	1	1915779	26	38749.58	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	1	74399
53	23985	29111	29	1	2158897	29	43667.01	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	1	83841
54	35744	43384	43	2	3217328	43	65075.40	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	2	124945
55	29434	35725	36	1	2649363	36	53587.44	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	1	102888
56	32498	39444	39	2	2925155	39	59165.75	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	2	113598
57	20535	24924	25	1	1848361	25	37385.95	2083.57	22572.14	8	56	65	4663054.29	65	1500	0	1	71781
58	35899	43572	44	2	3231280	44	65357.60	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	2	125487
59	21258	25801	26	1	1913439	26	38702.24	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	1	74308
60	29183	35420	35	1	2626770	35	53130.47	2083.57	22572.14	8	56	65	4663054.29	65	1500	1	1	102011
61	16415	19923	20	1	1477519	20	29885.09	2083.57	22572.14	8	56	65	4663054.29	65	1500	0	1	57379
62	74363	90257	90	4	6693436	90	135385.02	2083.57	22572.14	8	56	65	4663054.29	65	1500	2	4	259939
63	68502	83143	83	3	6165885	83	124714.51	2083.57	22572.14	8	56	65	4663054.29	65	1500	2	3	239452
64	68185	82758	83	3	6137352	83	124137.38	2425.33	24773.33	10	62	72	5157696.00	72	1500	2	3	238344
65	68054	82599	83	3	6125561	83	123898.88	2425.33	24773.33	10	62	72	5157696.00	72	1500	2	3	237886
66	47327	57442	57	2	4259917	57	86163.38	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	2	165434
67	33609	40792	41	2	3025156	41	61188.43	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	2	117482
68	34647	42052	42	2	3118587	42	63078.21	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	2	121110
69	25342	30758	31	1	2281041	31	46137.56	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	88584
70	25583	31051	31	1	2302733	31	46576.32	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	89427
71	13107	15908	16	1	1179765	16	23862.56	2425.33	24773.33	10	62	72	5157696.00	72	1500	0	1	45816
72	28872	35043	35	1	2598777	35	52564.27	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	100923
73	23976	29100	29	1	2158087	29	43650.62	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	83809
74	46416	56337	56	2	4177918	56	84504.81	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	2	162249
75	55735	67647	68	3	5016724	68	101470.95	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	3	194824

76	23136	28081	28	1	2082478	28	42121.32	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	80873
77	22457	27257	27	1	2021361	27	40885.14	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	78499
78	25686	31176	31	1	2312004	31	46763.84	2425.33	24773.33	10	62	72	5157696.00	72	1500	1	1	89787
79	25192	30576	31	1	2267539	31	45864.47	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	88060
80	30626	37172	37	1	2756655	37	55757.59	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	107055
81	22068	26785	27	1	1986347	27	40176.93	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	77140
82	20501	24883	25	1	1845301	25	37324.05	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	71662
83	20990	25476	25	1	1889316	25	38214.32	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	73371
84	15913	19314	19	1	1432334	19	28971.15	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	55625
85	13395	16258	16	1	1205688	16	24386.89	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	46823
86	15285	18552	19	1	1375807	19	27827.82	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	53429
87	15121	18353	18	1	1361046	18	27529.24	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	52856
88	20921	25392	25	1	1883105	25	38088.70	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	73130
89	16358	19854	20	1	1472388	20	29781.32	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	57180
90	16549	20086	20	1	1489580	20	30129.05	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	57848
91	21557	26164	26	1	1940352	26	39246.60	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	75353
92	18410	22345	22	1	1657090	22	33517.18	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	64353
93	17929	21761	22	1	1613795	22	32641.48	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	62672
94	21995	26696	27	1	1979776	27	40044.02	1401.18	6229.41	6	16	21	1524832.94	21	1500	1	1	76885
95	12387	15034	15	1	1114958	15	22551.73	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	43299
96	16608	20158	20	1	1494891	20	30236.47	1401.18	6229.41	6	16	21	1524832.94	21	1500	0	1	58054
97	25559	31022	31	1	2300573	31	46532.63	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	89343
98	17614	21379	21	1	1585441	21	32067.99	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	61571
99	19784	24012	24	1	1780764	24	36018.68	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	69156
100	13682	16606	17	1	1231521	17	24909.40	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	47826
101	16210	19675	20	1	1459067	20	29511.87	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	56663
102	11947	14500	15	1	1075353	15	21750.67	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	41761
103	17091	20744	21	1	1538366	21	31115.82	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	59742
104	24422	29642	30	1	2198231	30	44462.61	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	85368
105	19473	23635	24	1	1752770	24	35452.48	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	68069
106	22316	27086	27	1	2008670	27	40628.43	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	78007
107	26213	31816	32	1	2359440	32	47723.30	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	91629
108	30112	36548	37	1	2710390	37	54821.80	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	105258
109	23439	28449	28	1	2109751	28	42672.96	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	81932
110	16793	20382	20	1	1511543	20	30573.28	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	58701
111	21537	26140	26	1	1938552	26	39210.19	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	75284
112	17818	21626	22	1	1603803	22	32439.39	1918.24	10292.35	8	26	33	2405075.29	33	1500	0	1	62284
113	23888	28994	29	1	2150166	29	43490.41	1918.24	10292.35	8	26	33	2405075.29	33	1500	1	1	83502
114	34722	42143	42	2	3125337	42	63214.76	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	2	121372
115	25425	30859	31	1	2288512	31	46288.67	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	88874
116	25917	31456	31	1	2332797	31	47184.40	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	90594
117	29762	36123	36	1	2678886	36	54184.60	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	104034
118	29635	35969	36	1	2667455	36	53953.38	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	103590

119	23839	28934	29	1	2145755	29	43401.20	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	83330
120	29896	36286	36	1	2690948	36	54428.56	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	104503
121	26778	32501	33	1	2410296	33	48751.94	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	93604
122	32736	39733	40	2	2946577	40	59599.05	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	2	114430
123	22454	27253	27	1	2021091	27	40879.68	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	78489
124	20574	24971	25	1	1851872	25	37456.95	2571.88	17576.25	10	44	54	3904425.00	54	1500	0	1	71917
125	29261	35515	36	1	2633791	36	53272.48	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	102283
126	21521	26121	26	1	1937112	26	39181.06	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	75228
127	24918	30244	30	1	2242877	30	45365.63	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	1	87102
128	44712	54268	54	2	4024540	54	81402.52	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	2	156293
129	44234	53688	54	2	3981515	54	80532.27	2571.88	17576.25	10	44	54	3904425.00	54	1500	1	2	154622
130	44525	54041	54	2	4007708	54	81062.06	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	155639
131	50264	61007	61	2	4524278	61	91510.47	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	175700
132	38334	46527	47	2	3450455	47	69790.75	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	133998
133	23167	28119	28	1	2085269	28	42177.76	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	1	80981
134	25756	31261	31	1	2318305	31	46891.29	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	1	90031
135	41157	49954	50	2	3704554	50	74930.29	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	143866
136	24672	29945	30	1	2220734	30	44917.76	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	1	86242
137	22923	27822	28	1	2063306	28	41733.54	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	1	80128
138	36751	44606	45	2	3307968	45	66908.75	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	128465
139	31759	38547	39	2	2858637	39	57820.33	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	111015
140	30240	36703	37	1	2721911	37	55054.84	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	1	105705
141	45787	55573	56	2	4121301	56	83359.66	2256.67	17665.83	9	44	53	3829770.00	53	1500	1	2	160051
142	25642	31122	31	1	2308044	31	46683.74	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	1	89633
143	16855	20457	20	1	1517124	20	30686.16	3195.00	29602.86	13	74	87	6248674.29	87	1500	0	1	58917
144	19001	23062	23	1	1710286	23	34593.16	3195.00	29602.86	13	74	87	6248674.29	87	1500	0	1	66419
145	20483	24861	25	1	1843681	25	37291.28	3195.00	29602.86	13	74	87	6248674.29	87	1500	0	1	71599
146	24258	29443	29	1	2183470	29	44164.03	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	1	84795
147	18234	22131	22	1	1641248	22	33196.76	3195.00	29602.86	13	74	87	6248674.29	87	1500	0	1	63738
148	21464	26052	26	1	1931981	26	39077.29	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	1	75028
149	31730	38512	39	2	2856027	39	57767.53	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	2	110914
150	31688	38461	38	2	2852246	38	57691.07	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	2	110767
151	38366	46566	47	2	3453335	47	69849.01	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	2	134110
152	24555	29803	30	1	2210203	30	44704.75	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	1	85833
153	95818	116297	116	5	8624607	116	174445.93	3195.00	29602.86	13	74	87	6248674.29	87	1500	2	5	334936
154	41627	50524	51	2	3746859	51	75785.97	3195.00	29602.86	13	74	87	6248674.29	87	1500	1	2	145509
155	78007	94680	95	4	7021433	95	142019.28	3195.00	29602.86	13	74	87	6248674.29	87	1500	2	4	272677
Total	434364	5274023	5272	211	390972772	5272	7908025.32	306171.18	2481229.41	1225	6203	7428	534798592.9	7428	232500	105	211	15183409

APPENDIX D: COMPLETE REFERENCE LISTING

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ADDENDUM TO CHAPTER 3 (NIUA DATA)

Status of Water Supply, Sanitation and Solid Waste Management in Urban India

Statistical Volume III

Solid Waste Management
1999

National Institute of Urban Affairs
I & II Floor, Core 4B, India Habitat Centre, Lodhi Road, New Delhi – 110 003
June 2005

List of Abbreviations

Civic Status

CMC	City Municipal Council
CT	Census Town
M	Municipality
M.Corp.	Municipal Corporation
MB	Municipal Board
MC	Municipal Committee, Municipal Corporation
MCI	Municipal Council
NM	Non-municipal
NMCT	Non-municipal Census Town
NTAC	Notified Town Area Committee
TC	Town Committee

Others

ltrs.	litres
kl.	kilolitre (1000 litres)
lpcd	litres per capita per day
mld	million litres daily
mld	metre
km.	kilometre
sq.km.	square kilometre
n.a.	not available
n.r.	not reliable
lakh	100,000
crore	10,000,000

List of Sampled Cities and Towns

Metropolitan Cities

	Towns	State
1	Ahmedabad M.Corp.	Gujarat
2	Bangalore M.Corp.	Karnataka
3	Bhopal M.Corp.	Madhya Pradesh
4	Calcutta M.Corp.	Calcutta
5	Chennai M.Corp.	Tamil Nadu
6	Coimbatore M.Corp	Tamil Nadu
7	Delhi M.Corp.	Delhi
8	Greater Mumbai M.Corp.	Maharashtra
9	Hyderabad M.Corp.	Andhra Pradesh
10	Indore M.Corp.	Madhya Pradesh
11	Jaipur M.Corp.	Rajasthan
12	Kanpur M.Corp.	Uttar Pradesh
13	Kochi M.Corp.	Kerala
14	Lucknow M.Corp.	Uttar Pradesh
15	Ludhiana M.Corp.	Punjab
16	Madurai M.Corp.	Tamil Nadu
17	Nagpur M.Corp.	Maharashtra
18	Pune M.Corp.	Maharashtra
19	Surat M.Corp.	Gujarat
20	Vadodara M.Corp.	Gujarat
21	Varanasi M.Corp.	Uttar Pradesh
22	Visakhapatnam M.Corp.	Andhra Pradesh

Andhra Pradesh

Class I		Class II	
1	Anantapur MCI	1	Anakapalle M
2	Chittoor M	2	Dharmavaram M
3	Cuddapah MCI	3	Gudur MCI
4	Eluru M	4	Kapra M
5	Guntur MCI	5	Kavali MCI
6	Hindupur M	6	Madanapalle M
7	Kakinada M	7	Narasaraopet M
8	Kurnool MCI	8	Rajendra nagar MCI
9	Machilipatnam M	9	Sangareddy MCI
10	Nandyal MCI	10	Srikakulam MCI
11	Nellore MCI	11	Srikalahasti M
12	Nizamabad M	12	Suryapet MCI
13	Ongole MCI		
14	Qutubullapur M		
15	Rajahmundry M.Corp.		
16	Tenali M		
17	Tirupati MCI		
18	Vijaywada M.Corp.		
19	Warangal M.Corp.		

Bihar

Class I		Class II	
1	Bihar Sharif M	7	Buxar M
2	Chhapra M	8	Deoghar M
3	Gaya M.Corp.	9	Hajipur M
4	Katihar M	10	Hazaribagh M
5	Munger M	11	Jehanabad M
6	Ranchi M.Corp.	12	Madhubani M
		13	Mokama M

Gujarat

Class I		Class II	
1	Anand M	12	Amreli M
2	Bharuch M	13	Ankleswar M
3	Bhavnagar M.Corp.	14	Dabhoi M
4	Bhuj M	15	Dohad M
5	Jamnagar M.Corp.	16	Gondal M
6	Junagadh M	17	Jetpur M
7	Nadiad M	18	Mahesana M
8	Navsari M	19	Palanpur M
9	Porbandar M		
10	Rajkot M.Corp.		
11	Surendranagar M		

Haryana

Class I		Class II	
1	Ambala MCI	7	Jind MCI
2	Faridabad M.Corp.	8	Kaithal MCI
3	Gurgaon MCI	9	Rewari MCI
4	Hisar MCI	10	Thanesar MCI
5	Karnal MCI		
6	Rohtak MCI		

Jammu & Kashmir

Class I	
1	Jammu M.Corp.
2	Srinagar M.Corp.

Karnataka

Class I		Class II	
1	Belgaum M.Corp.	12	Bagalkot CMC
2	Bellary CMC	13	Chikmaglur CMC
3	Davangere MCI	14	Gokak CMC
4	Gadag-Betigeri CMC	15	Hospet CMC
5	Gulbarga M.Corp.	16	Kolar CMC
6	Hubli-Dharwar M.Corp.	17	Rabkavi-Banhatti CMC
7	Mandya M	18	Ramanagaram CMC
8	Mangalore M.Corp.		
9	Mysore M.Corp.		
10	Shimoga CMC		
11	Tumkur M		

Kerala

Class I		Class II	
55	Alappuzha MC	39	Changanessary MC
56	Kollam MC	40	Payyanur M
57	Kozhikode M.Corp.	41	Taliparamba M
58	Thalaserry M	42	Thrissur MC
59	Thiruvananthapuram M.Corp.		

Madhya Pradesh

	Class I		Class II
1	Bhind M	14	Hoshangabad M
2	Burhanpur M.Corp.	15	Itarsi M
3	Dewas M.Corp.	16	Khargone M
4	Guna M	17	Mandsaur M
5	Gwalior M.Corp.	18	Nagda M
6	Jabalpur M.Corp.	19	Neemuch M
7	Khandwa M	20	Sehore M
8	Morena M	21	Shahdol M
9	Murwara (Katni) M.Corp.	22	Vidisha M
10	Ratlam M.Corp.		
11	Rewa M.Corp.		
12	Satna M.Corp.		
13	Shivpuri M		

Maharashtra

	Class I		Class II
1	Amravati M.Corp.	15	Amalner MCl
2	Aurangabad M.Corp.	16	Ballarpur MCl
3	Bhusawal MCl	17	Bhandara M
4	Chandrapur MCl	18	Kamptee MCl
5	Dhule MCl	19	Manmad MCl
6	Ichalkaranji MCl	20	Ratnagiri MCl
7	Jalgaon MCl	21	Satara MCl
8	Kolhapur M.Corp.	22	Virar MCl
9	Nanded Waghala M.Corp.		
10	Nashik M.Corp.		
11	Parbhani MCl		
12	Solapur M.Corp.		
13	Wardha M		
14	Yavatmal MCl		

Orissa

	Class I		Class II
1	Bhubaneswar M.Corp.	6	Balangir M
2	Cuttack M.Corp.	7	Bhadrak M
3	Puri M		
4	Rourkela M		
5	Sambalpur M		

Punjab

	Class I		Class II
1	Amritsar M.Corp.	8	Firozpur MCl
2	Bathinda MCl	9	Kapurthala M
3	Hoshiarpur MCl	10	Mansa MCl
4	Jalandhar M.Corp.	11	Phagwara MCl
5	Moga MCl	12	Sangrur MCl
6	Pathankot MCl		
7	Patiala M.Corp.		

Rajasthan

	Class I		Class II
1	Ajmer MCl	9	Banswara M
2	Alwar M	10	Barmer M
3	Beawar M	11	Bundi M
4	Bhilwara M	12	Churu M
5	Bikaner M	13	Hanumangarh M
6	Jodhpur M.Corp.	14	Sawai Madhopur M
7	Kota M.Corp.		
8	Sriganganagar M		

Tamil Nadu

	Class I		Class II
1	Cuddalore M	16	Ambur M
2	Dindigul M	17	Arakkonam M
3	Erode M	18	Attur M
4	Kanchipuram M	19	Cumbum M
5	Kumbakonam M	20	Dharmapuri M
6	Nagercoil M	21	Guduivattam M
7	Rajapalayam M	22	Nagapattinam M
8	Salem M.Corp.	23	Pudukkottai M
9	Thanjavur M	24	Sivakasi M
10	Tiruchirapalli M.Corp.	25	Srivilliputtur M
11	Tirunelveli M.Corp.	26	Tindivanam MC
12	Tirunvannamalai M	27	Udhagamandalam M
13	Tiruppur M		
14	Tuticorin M		
15	Vellore M		

Uttar Pradesh

	Class I		Class II
1	Agra M.Corp.	24	Auraiya MB
2	Aligarh M.Corp.	25	Balrampur MB
3	Allahabad M.Corp.	26	Basti MB
4	Bareilly M.Corp.	27	Bhadohi MB
5	Etawah MB	28	Chandpur MB
6	Faizabad MB	29	Etah MB
7	Firozabad MB	30	Ghazipur MB
8	Ghaziabad M.Corp.	31	Gonda MB
9	Gorakhpur M.Corp.	32	Lakhimpur MB
10	Haldwani-cum-Kathgodam MB	33	Lalitpur MB
11	Hapur MB	34	Mughalsarai MB
12	Hardwar MB	35	Nawabganj-Barabanki MB
13	Jhansi MB	36	Orai MB
14	Mathura MB	37	Roorkee MB
15	Meerut M.Corp.		
16	Mirzapur MB		
17	Moradabad M.Corp.		
18	Muzaffarnagar MB		
19	Rae Bareli MB		
20	Rampur MB		
21	Saharanpur MB		
22	Sitapur MB		
23	Unnao MB		

West Bengal

	Class I		Class II
1	Asansol M.Corp.	13	Bishnupur M
2	Baharampur M	14	Chakdaha M
3	Balurghat M	15	Contai M
4	Bankura M	16	Cooch Behar M
5	Barasat M	17	Darjeeling M
6	Burdwan M	18	Jalpaiguri M
7	Halisahar M	19	Jangipur M
8	Krishnagar M	20	Katwa M
9	Midnapore M	21	Raniganj M
10	North Barrackpore M		
11	Santipur M		
12	Silliguri M.Corp.		

Small States and Union Territories

	Class I		Class II
	Assam		**Himachal Pradesh**
1	Guwahati M.Corp.	1	Shimla M.Corp.
2	Jorhat MB		**Nagaland**
	Manipur	1	Kohima TC
1	Imphal MCl		**Union Teritories**
	Meghalaya	1	Port Balir MCl
1	Shillong MB		
	Mizoram		
1	Aizwal NM		
	Tripura		
1	Agartala MCl		
	Union Territories		
	Chandigarh		
1	Chandigarh M.Corp.		
	Pondicherry		
2	Pondicherry M		

Other Classes

	States		Union Territories
	Arunachal Pradesh		**Daman and Diu**
1	Itanagar CT	1	Daman MCl
	Goa		**Lakshadweep Islands**
1	Panaji MCl	1	Kavarathi NMCT
	Sikkim		**Dadra and Nagar Haveli**
1	Gangtok	1	Silvassa

List of Tables
Waste Water Collection, Treatment and Disposal

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
	Metropolitan Cities								
1	Ahmedabad M.Corp.	2,877	3,500	100	186.78	190.84	100	1,179,000	1,435,000
2	Bangalore M.Corp.	2,660	5,000	100	125.90	227.00	100	399,013	750,000
3	Bhopal M.Corp.	1,063	1,500	100	284.09	284.09	100	n.a.	230,512
4	Calcutta M.Corp.	4,400	4,870	100	187.33	187.33	100	2,000,000	2,290,000
5	Chennai M.Corp.	3,841	4,363	100	174.00	174.00	100	n.a.	1,500,000
6	Coimbatore M.Corp.	816	971	100	105.60	105.60	100	n.a.	n.a.
7	Delhi M.Corp.	7,207	12,000	63	1399.26	1484.46	n.a.	1,300,000	3,000,000
8	Greater Mumbai M.Corp.	9,926	11,100	100	437.71	437.71	100	4,459,000	5,823,510
9	Hyderabad M.Corp.	2,965	4,163	100	172.68	172.68	100	n.a.	601,336
10	Indore M.Corp.	1,092	1,600	75	137.17	137.17	75	264,000	300,000
11	Jaipur M.Corp.	1,458	2,000	100	200.40	200.40	100	214,000	433,000
12	Kanpur M.Corp.	1,874	2,500	86	106.00	227.67	n.a.	200,000	500,000
13	Kochi M.Corp.	565	680	100	94.88	94.88	100	52,090	69,500
14	Lucknow M.Corp.	1,619	2,500	70	310.10	310.00	90	120,000	200,000
15	Ludhiana M.Corp.	1,043	2,000	40**	134.67	165.00	40	350,000	700,000
16	Madurai M.Corp.	941	1,020	100	46.99	51.96	100	195,266	310,000
17	Nagpur M.Corp.	1,625	2,100	100	217.17	217.56	100	650,000	890,000
18	Pune M.Corp.	1,567	2,300	100	146.11	416.11	100	628,000	879,200
19	Surat M.Corp.	1,499	2,300	100	111.16	111.16	100	450,000	750,000
20	Vadodara M.Corp.	1,031	1,400	100	108.26	108.26	100	185,000	250,000
21	Varanasi M.Corp.	929	1,152	81	73.89	73.89	81	160,854	265,027
22	Visakhapatnam M.Corp.	752	1,280	100	78.33	107.00	100	n.a.	265,000
	Total-Metropolitan Cities	**51,749**	**70,299**	**90**	**4838.48**	**5484.77**			

* Estimated by respective local governments / relevant agencies ** Remaining population of Ludhiana is covered by CBOs

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
	Class I								
	Andhra Pradesh								
1	Anantapur MCl	175	250	100	16.35	16.35	100	55,000	70,000
2	Chittoor M	133	149	100	33.57	33.57	100	40,907	41,928
3	Cuddapah MCl	121	166	100	7.50	7.50	100	25,023	29,364
4	Eluru M	213	247	100	14.55	14.55	100	62,000	78,000
5	Guntur MCl	471	557	100	30.01	45.79	100	n.a.	157,015
6	Hindupur M	105	140	100	38.16	38.16	100	n.a.	41,203
7	Kakinada M	280	325	85	30.51	30.51	85	62,230	91,940
8	Kurnool MCl	237	282	100	15.01	15.01	100	83,634	93,624
9	Machilipatnam M	159	200	100	26.67	26.67	100	n.a.	13,600
10	Nandyal MCl	120	150	100	15.42	15.42	100	30,292	38,362
11	Nellore MCl	317	404	100	48.39	48.39	100	93,900	119,000
12	Nizamabad M	241	285	100	36.86	36.86	100	n.a.	109,144
13	Ongole MCl	101	180	100	8.24	8.24	100	24,034	27,232
14	Qutubullapur M	107	250	100	46.87	46.87	100	n.a.	67,489
15	Rajahmundry M.Corp.	325	380	100	38.90	44.50	100	52,000	78,000
16	Tenali M	144	170	100	15.11	15.11	100	n.a.	42,592
17	Tirupati MCl	174	210	100	16.07	24.00	100	44,680	54,000
18	Vijaywada M.Corp.	702	837	100	57.33	57.33	100	240,000	300,000
19	Warangal M.Corp.	448	680	100	54.98	68.50	100	36,492	40,684
	Bihar								
20	Bihar Sharif M	201	250	100	23.50	23.50	100	82,099	135,938
21	Chhapra M	137	200	95	16.96	16.96	n.a.	n.a.	n.a.
22	Gaya M.Corp.	292	400	100	28.62	28.62	100	42,169	n.a.
23	Katihar M	135	200	100	12.00	12.00	100	n.a.	n.a.
24	Munger M	150	210	67	17.50	19.00	84	n.a.	n.a.
25	Ranchi M.Corp.	599	700	85	177.19	177.19	85	n.a.	n.a.
	Gujarat								
26	Anand M	110	175	100	21.13	23.14	100	32,000	40,000
27	Bharuch M	133	159	100	18.43	19.93	100	10,000	15,000
28	Bhavnagar M.Corp.	402	550	100	90.16	n.a.	n.a.	48,397	50,935

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

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		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
29	Bhuj M	102	118	100	9.48	9.49	100	15,000	20,000
30	Jamnagar M.Corp.	342	500	100	26.40	26.40	100	90,214	101,824
31	Junagadh M	130	165	100	13.47	n.a.	n.a.	n.a.	n.a.
32	Nadiad M	167	300	100	28.48	28.48	100	25,000	40,000
33	Navsari M	126	139	100	8.52	8.55	100	25,000	30,000
34	Porbandar M	117	142	100	12.30	12.30	100	8,100	9,500
35	Rajkot M.Corp.	559	1,000	100	69.00	104.86	100	90,000	125,000
36	Surendranagar M	106	150	100	14.19	36.87	100	10,082	n.a.
	Haryana								
37	Ambala MCl	119	141	85	16.94	16.94	85	11,720	18,550
38	Faridabad M.Corp.	618	1,150	100	178.00	208.00	100	130,000	150,000
39	Gurgaon MCl	121	175	85	15.33	16.57	85	31,390	37,863
40	Hissar MCl	173	250	75	45.42	45.42	100	42,525	52,100
41	Karnal MCl	174	220	72	22.10	22.10	60	41,300	46,000
42	Rohtak MCl	216	243	100	20.38	28.38	100	66,945	103,351
	Jammu & Kashmir								
43	Jammu M.Corp.	716*	909	100	n.a.	130.36	n.a.	n.a.	n.a.
44	Srinagar M.Corp.		800	n.a.	n.a.	210.00	n.a.	n.a.	n.a.
	Karnataka								
45	Belgaum M.Corp.	326	470	100	83.93	n.a.	n.a.	100,000	120,000
46	Bellary CMC	245	297	100	65.90	81.95	100	61,990	95,000
47	Davangere MCl	266	455	99	20.51	n.a.	n.a.	72,000	140,392
48	Gadag-Betigeri CMC	134	148	100	34.75	n.a.	n.a.	7,285	9,276
49	Gulbarga M.Corp.	304	450	100	32.14	55.00	100	48,000	89,000
50	Hubli-Dharwad M.Corp.	648	850	100	190.94	190.94	100	102,000	270,000
51	Mandya M	120	140	100	17.03	17.03	100	n.a.	8,000
52	Mangalore M.Corp.	273	410	100	73.71	116.77	100	16,690	n.a.
53	Mysore M.Corp.	481	1,050	100	36.69	n.a.	n.a.	52,200	69,500
54	Shimoga CMC	179	222	100	16.26	n.a.	n.a.	8,000	42,000
55	Tumkur M	139	300	60	15.32	45.90	n.a.	10,000	22,800

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
	Kerala								
56	Alappuzha MC	175	200	100	46.77	46.77	100	42,170	53,000
57	Kollam MC	140	160	100	18.48	18.48	100	33,500	45,000
58	Kozhikode M.Corp.	420	493	100	82.68	84.23	100	71,300	73,000
59	Thalaserry M	104	134	100	23.96	n.a.	n.a.	10,000	11,200
60	Thiruvananthapuram M.Corp.	524	585	100	74.93	78.40	100	20,000	25,000
	Madhya Pradesh								
61	Bhind M	110	175	44	17.18	17.18	47	3,000	3,200
62	Burhanpur M.Corp.	173	210	100	24.00	24.00	100	n.a.	84,000
63	Dewas M.Corp.	164	200	100	100.22	100.22	100	n.a.	n.a.
64	Guna M	100	125	100	45.75	45.75	100	24,750	38,950
65	Gwalior M.Corp.	691	900	100	289.85	n.a.	n.a.	200,000	270,000
66	Jabalpur M.Corp.	742	1,000	100	133.97	133.97	100	n.a.	n.a.
67	Khandwa M	145	175	100	35.77	35.77	100	35,000	n.a.
68	Morena M	105*	125	100	12.00*	12.00	100	20,000	25,000
69	Murwara-Katni M.Corp.	163	180	100	107.10	107.10	100	n.a.	n.a.
70	Ratlam M.Corp.	183	235	85	39.19	39.19	85	62,000	70,000
71	Rewa M.Corp.	129	180	100	54.99	54.99	100	n.a.	n.a.
72	Satna M.Corp.	157	200	100	86.77	n.a.	n.a.	4,000	5,000
73	Shivpuri M	108	140	100	81.10	81.10	100	22,800	28,470
	Maharashtra								
74	Amravati M.Corp.	422	500	100	121.65	121.65	100	100,000	150,000
75	Aurangabad M.Corp.	573	868	100	138.50	138.50	100	170,000	270,000
76	Bhusawal M.Cl.	145	200	85	13.38	13.38	78	13,100	n.a.
77	Chandrapur MCl	226	295	100	56.28	56.28	100	n.a.	80,753
78	Dhule MCl	278	330	100	46.46	46.46	100	35,000	55,000
79	Ichalkaranji MCl	215	250	100	29.89	29.89	100	22,000	30,000
80	Jalgaon MCl	242	400	100	62.29	65.64	100	75,000	75,000
81	Kolhapur M.Corp.	406	502	100	66.82	66.82	100	41,970	68,395
82	Nanded Waghala M.Corp.	275	410	100	20.62	46.00	100	n.a.	71,190
83	Nashik M.Corp.	657	839	100	259.13	259.13	100	140,000	200,000

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

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		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
84	Parbhani MCl	190	233	100	n.a.	57.60	100	58,774	125,000
85	Solapur M.Corp.	604	900	100	33.11	n.a.	n.a.	n.a.	240,000
86	Wardha M	103	150	100	7.77	9.04	100	16,900	19,617
87	Yavatmal MCl	109	130	100	10.17	10.69	100	39,000	40,000
	Orissa								
88	Bhubaneswar M.Corp.	412	654	100	124.74	n.a.	n.a.	103,730	n.a.
89	Cuttack M.Corp.	403	563	100	121.91	121.91	n.a.	90,798	n.a.
90	Puri M	125	150	100	16.84	n.a.	n.a.	n.a.	n.a.
91	Rourkela M	140	200	100	33.00	n.a.	n.a.	n.a.	n.a.
92	Sambalpur M	131	157	100	46.48	n.a.	n.a.	n.a.	n.a.
	Punjab								
93	Amritsar M.Corp.	709	843	95	114.95	133.00	80	246,675	253,000
94	Bathinda MCl	159	174	40	97.00	99.00	n.a.	24,250	27,911
95	Hoshiarpur MCl	123	145	76	28.21	35.00	76	n.a.	28,000
96	Jalandhar M. Corp.	510	738	91	80.41	110.00	91	200,000	150,000
97	Moga MCl	108	148	80	16.10	18.50	81	13,835	18,447
98	Pathankot MCl	124	195	100	22.10	22.10	100	11,000	11,000
99	Patiala M.Corp.	238	328	100	31.20	41.00	100	80,000	70,000
	Rajasthan								
100	Ajmer MCl	403	550	100	241.58	n.a.	n.a.	111,897	150,000
101	Alwar M	205	300	90	48.40	58.15	90	20,000	25,000
102	Beawar M	105	141	100	17.69	17.69	100	n.a.	2,130
103	Bhilwara M	184	225	100	118.49	n.a.	n.a.	37,000	45,000
104	Bikaner M	416	600	100	165.75	175.76	100	14,400	24,500
105	Jodhpur M.Corp.	666	1,000	100	78.60	n.a.	n.a.	194,400	280,500
106	Kota M.Corp.	537	750	100	221.36	221.36	100	n.a.	n.a.
107	Sriganganagar M	161	225	100	20.87	20.87	100	8,500	11,000
	Tamil Nadu								
108	Cuddalore M	145	162	100	27.71	27.71	100	28,020	34,000
109	Dindigul M	182	214	100	14.01	14.01	100	21,680	27,000
110	Erode M	159	174	100	8.44	8.44	100	37,190	40,000

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

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		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
111	Kanchipuram M	145	157	100	11.60	11.60	100	n.a.	n.a.
112	Kumbakonam M	139	147	100	12.58	12.58	100	48,819	51,892
113	Nagercoil M	190	206	100	24.27	24.27	100	10,500	12,648
114	Rajapalaiyam M	114	123	100	11.36	11.36	100	15,770	17,000
115	Salem M.Corp.	367	447	100	19.94	19.94	100	62,000	125,300
116	Thanjavur M	202	217	100	15.36	n.a.	n.a.	38,040	41,000
117	Tiruchirapalli M.Corp.	669*	800	100	23.00	n.a.	n.a.	n.a.	167,162
118	Tirunelveli M.Corp.	374*	414	100	15.15	n.a.	n.a.	82,810	93,520
119	Tirunvannamalai M	109	129	100	13.64	13.64	100	21,000	34,000
120	Tiruppur M	236	295	100	43.52	n.a.	n.a.	n.a.	63,094
121	Tuticorin M	200	217	100	13.47	13.47	100	32,350	35,000
122	Vellore M	175	176	100	11.65	11.65	100	45,887	65,587
	Uttar Pradesh								
123	Agra M.Corp.	892	1,150	75	120.57	120.57	n.a.	n.a.	n.a.
124	Aligarh M.Corp.	481	600	75	34.05	n.a.	n.a.	n.a.	n.a.
125	Allahabad M.Corp.	793	1,015	90	62.94	70.05	90	83,160	106,122
126	Bareilly M.Corp.	587	750	100	106.43	106.43	100	n.a.	n.a.
127	Etawah MB	124	140	100	9.35	n.a.	n.a.	678	2,750
128	Faizabad MB	124	170	70	33.47	33.47	n.a.	n.a.	n.a.
129	Firozabad MB	215	250	60	9.17	n.a.	n.a.	n.a.	n.a.
130	Ghaziabad M.Corp.	454	887	100	63.79	n.a.	n.a.	n.a.	n.a.
131	Gorakhpur M.Corp.	506	600	80	136.58	143.00	80	76,000	90,000
132	Haldwani-cum-Kathgodam MB	104	141	100	10.62	10.62	100	16,854	n.a.
133	Hapur MB	146	200	75	14.20	14.20	70	1,500	2,000
134	Hardwar MB	147	300	100	11.91	11.91	100	27,000	40,000
135	Jhansi MB	301	507	75	46.32	46.32	n.a.	120,000	170,000
136	Mathura MB	227	400	67	9.37	n.a.	n.a.	n.a.	80,000
137	Meerut M.Corp.	754	1,250	100	141.94	141.94	100	n.a.	n.a.
138	Mirzapur MB	169	210	81	38.85	38.85	62	26,000	31,500
139	Moradabad M.Corp.	429	670	72	34.19	50.48	80	n.a.	n.a.
140	Muzaffarnagar MB	241	325	80	12.04	12.04	80	42,471	57,966
141	Rae Bareli MB	130	175	75	50.12	n.a.	n.a.	14,846	29,750

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		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
142	Rampur MB	244	317	100	20.20	n.a.	n.a.	n.a.	n.a.
143	Saharanpur MB	375	540	50	25.36	25.36	51	142,000	175,000
144	Sitapur MB	122	150	100	25.90	35.00	100	n.a.	n.a.
145	Unnao MB	107	121	100	15.54	21.50	100	10,000	13,000
	West Bengal								
146	Asansol M.Corp.	262	315	100	25.12	n.a.	n.a.	n.a.	n.a.
147	Baharampur M	115	143	100	16.19	16.19	100	32,000	55,690
148	Balurghat M	120	132	100	6.37	8.50	100	40,000	52,000
149	Bankura M	115	151	95	19.06	19.06	100	25,000	33,000
150	Barasat M	103	150	67	20.25	34.50	75	39,000	64,845
151	Burdwan M	245	323	84	23.04	34.18	84	97,000	110,000
152	Halisahar M	114	149	n.a.	8.28	n.a.	n.a.	47,919	n.a.
153	Krishna Nagar M	121	145	100	15.96	15.96	100	50,523	60,603
154	Midnapur M	125	158	100	14.78	18.85	100	42,000	59,000
155	North Barrackpur M	101	118	100	8.42	12.22	100	17,548	22,500
156	Santipur M	110	134	100	24.60	25.88	100	60,000	64,000
157	Siliguri M.Corp.	338*	500	64	15.54	41.90	64	42,000	157,000
	Small States								
	Assam								
158	Guwahati M.Corp.	584	1,400	100	216.79	216.79	100	95,000	105,000
159	Jorhat MB	112	170	100	9.20	n.a.	n.a.	18,600	n.a.
	Manipur								
160	Imphal MCl	199	245	100	33.30	33.30	100	0	0
	Meghalaya								
161	Shillong MB	132	217	100	10.36	10.36	100	n.a.	n.a.
	Tripura								
162	Agartala MCl	157	200	100	15.80	16.01	100	25,000	27,000
	Union Territories								
163	Chandigarh M.Corp.	504	850	94	69.52	n.a.	n.a.	n.a.	n.a.
164	Pondicherry M	203	290	100	19.54	19.54	100	40,500	58,000

* Estimated by respective local governments / relevant agencies

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

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	1	2	3	4	5	6	7	8	9
	Class II								
	Andhra Pradesh								
1	Anakapalle M	84	115	100	23.28	23.28	100	20,942	22,000
2	Dharmavaram M	79	100	100	40.45	40.45	100	36,322	46,982
3	Gudur MCl	56	72	100	9.42	9.42	100	19,402	21,000
4	Kapra M	88	120	80	43.90	65.00	80	23,887	30,387
5	Kavali MCl	66	85	100	22.95	22.95	100	25,168	30,000
6	Madanapalle M	74	100	100	7.74	14.20	100	13,283	15,975
7	Narasaraopet M	89	95	93	7.65	7.65	93	40,594	45,244
8	Rajendra Nagar MCl	85	120	100	52.25	52.25	100	24,346	26,281
9	Sangareddy MCl	50	60	100	13.60	13.69	100	23,225	25,246
10	Srikakulam MCl	89	100	100	14.12	14.12	100	37,375	n.a.
11	Srikalahasti M	62	70	100	24.50	n.a.	n.a.	14,000	20,506
12	Suryapet MCl	61	89	100	23.54	11.50	100	42,931	49,000
	Bihar								
13	Buxar M	56	67	82	5.16	8.50	82	14,270	15,500
14	Deoghar M	76	100	100	n.a.	n.a.	n.a.	n.a.	n.a.
15	Hajipur M	88	115	100	19.64	19.64	100	26,000	30,000
16	Hazaribagh M	98	119	100	26.35	n.a.	n.a.	n.a.	n.a.
17	Jehanabad M	52	57	88	8.00	7.00	88	9,351	11,225
18	Madhubani M	54	65	77	19.00	19.00	77	n.a.	n.a.
19	Mokama M	60	66	n.a.	14.18	n.a.	n.a.	n.a.	36,000
	Gujarat								
20	Amreli M	68	85	100	11.44	13.59	100	n.a.	n.a.
21	Ankleswar M	52	60	100	11.05	11.05	100	15,000	16,000
22	Dabhoi M	51	65	100	23.82	23.82	100	8,000	10,000
23	Dohad M	67	78	100	6.54	7.00	100	3,000	7,000
24	Gondal M	81	100	100	7.29	11.00	100	15,000	20,000
25	Jetpur M	74	125	100	10.36	36.00	100	12,000	20,000
26	Mahesana M	88	138	100	12.87	12.87	100	18,000	24,000
27	Palanpur M	81	117	100	14.92	23.48	100	20,000	30,000
	Haryana								
28	Jind MCl	85	114	70	15.30	15.00	70	22,550	26,160
29	Kaithal MCl	71	95	81	7.90	n.a.	n.a.	7,874	26,286
30	Rewari MCl	75	105	100	18.43	n.a.	n.a.	29,600	34,236
31	Thanesar MCl	81	100	72	32.25	32.25	72	23,746	38,687

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
	Karnataka								
32	Bagalkot CMC	77	100	85	33.59	42.00	85	15,360	23,500
33	Chikmagalur CMC	61	100	100	9.32	n.a.	n.a.	8,000	12,000
34	Gokak CMC	52	68	100	7.22	n.a.	n.a.	10,000	13,500
35	Hospet CMC	96	114	100	7.66	n.a.	n.a.	30,000	32,000
36	Kolar CMC	83	112	100	7.91	n.a.	n.a.	16,643	22,000
37	Rabkavi-Banhatti CMC	61	72	100	3.62	n.a.	n.a.	5,700	7,099
38	Ramanagaram CMC	50	70	100	4.96	n.a.	n.a.	8,000	20,000
	Kerala								
39	Changanessary MC	52	62	100	13.50	13.50	100	15,000	25,000
40	Payyanur M	64	71	100	54.63	54.63	100	1,000	1,100
41	Taliparamba M	60	52	100	43.08	18.21	100	0	0
42	Thrissur MC	75	91	100	12.65	16.65	100	17,900	21,000
	Madhya Pradesh								
43	Hoshangabad M	71	100	100	24.27	24.27	100	n.a.	n.a.
44	Itarsi M	77	105	100	14.07	14.07	100	n.a.	n.a.
45	Khargone M	67	80	100	10.00	10.00	100	30,000	35,000
46	Mandsaur M	96	123	100	10.32	10.32	100	n.a.	10,000
47	Nagda M	80	100	80	23.83	18.00	100	17,000	18,685
48	Neemuch M	86	100	100	13.42	13.42	100	40,465	44,962
49	Sehore M	71	100	100	16.42	18.00	100	11,434	n.a.
50	Shahdol M	56	75	100	19.92	19.92	100	12,000	15,000
51	Vidisha M	93	125	100	5.83	5.83	100	23,229	26,423
	Maharashtra								
52	Amalner MCl	76	100	100	9.71	9.71	100	18,000	24,000
53	Ballarpur MCl	84	109	100	16.51	n.a.	n.a.	n.a.	n.a.
54	Bhandara M	72	76	100	16.84	16.84	100	28,970	37,661
55	Kamptee MCl	79	95	100	4.27	4.27	100	n.a.	n.a.
56	Manmad MCl	61	87	100	28.70	28.70	100	n.a.	n.a.
57	Ratnagiri MCl	57	70	100	10.49	10.19	100	9,065	11,594
58	Satara MCl	95	100	100	7.69	8.16	100	21,620	25,000
59	Virar MCl	58	100	100	19.52	19.52	100	11,520	20,000
	Punjab								
60	Ferozepur MCl	79	93	80	11.33	9.00	80	11,300	15,400
61	Kapurthala M	65	85	63	56.00	56.00	63	8,400	8,400

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
62	Mansa MCl	55	67	100	20.00	23.47	100	10,427	11,265
63	Phagwara MCl	83	108	80	16.00	12.80	80	10,424	8,610
64	Sangrur MCl	56	70	75	13.90	18.00	75	10,950	20,500
	Rajasthan								
65	Banswara M	67	110	100	16.01	16.01	100	n.a.	n.a.
66	Barmer M	69	84	100	10.29	10.29	100	13,000	16,000
67	Bundi M	65	80	100	22.76	30.00	100	15,000	18,000
68	Churu M	82	100	100	28.00	35.00	100	6,000	7,260
69	Hanumangarh M	79	125	100	13.42	13.42	100	4,000	5,000
70	Sawai Madhopur M	72	89	100	59.00	59.00	100	12,433	15,000
	Tamil Nadu								
71	Ambur M	76	86	100	18.05	18.05	100	22,900	23,500
72	Arakkonam M	72	88	100	9.06	9.06	100	14,000	15,000
73	Attur M	56	64	100	27.62	27.62	100	7,125	9,000
74	Cumbum M	52	54	100	6.48	6.58	100	10,656	10,656
75	Dharmapuri M	59	67	100	11.65	11.65	100	26,809	30,000
76	Gudiyatham M	83	95	100	4.71	4.71	100	16,425	18,000
77	Nagapattinam M	86	112	100	14.80	14.80	100	12,557	16,160
78	Pudukkottai M	99	108	100	12.95	12.95	100	34,673	38,000
79	Sivakasi M	66	70	100	6.89	6.89	100	4,720	5,000
80	Srivilliputtur M	69	74	100	5.72	5.72	100	12,800	13,000
81	Tindivanam M	62	70	100	22.37	22.37	100	26,109	29,700
82	Udhagamandalam M	82	100	100	30.67	30.67	100	n.a.	13,620
	Uttar Pradesh								
83	Auraiya MB	51	90	100	4.24	9.00	100	n.a.	n.a.
84	Balrampur MB	60	70	86	14.25	n.a.	n.a.	9,500	12,500
85	Basti MB	87	110	91	19.43	19.43	91	n.a.	n.a.
86	Bhadohi MB	64	125	40	10.36	n.a.	n.a.	10,300	15,180
87	Chandpur MB	56	80	50	1.53	n.a.	n.a.	15,000	30,000
88	Etah MB	78	135	65	5.18	n.a.	n.a.	10,000	25,000
89	Ghazipur MB	77	96	70	13.73	9.45	70	30,627	35,527
90	Gonda MB	96	114	100	12.67	12.67	100	10,000	12,000
91	Lakhimpur MB	80	100	100	6.99	9.00	100	11,900	15,000
92	Lalitpur MB	80	100	90	17.35	10.84	100	30,000	40,500

STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT

C-1: Population, Area and Coverage, 1999

Sl. No.	City/Town	Population '000		% population covered by service 1999	Area (sq. km.)		% area covered by service 1999	Slum population	
		1991 (Census)	1999 (Estimated)*		1991 (Census)	1999 (Estimated)*		1991 (Estimated*)	1999 (Estimated)*
	1	2	3	4	5	6	7	8	9
93	Mughalsarai MB	67	160	75	3.89	n.a.	n.a.	14,648	38,353
94	Nawabganj-Barabanki MB	65	90	100	3.63	n.a.	n.a.	n.a.	n.a.
95	Orai MB	99	170	75	20.29	15.00	100	20,000	35,000
96	Roorkee MB	80	100	85	n.a.	n.a.	n.a.	n.a.	n.a.
	West Bengal								
97	Bishnupur M	56	67	100	22.02	22.02	100	14,250	19,380
98	Chakdaha M	75	90	50	15.54	7.68	100	n.a.	40,090
99	Contai M	53	114	66	14.25	9.50	100	25,947	40,200
100	Cooch Behar M	71	99	100	8.29	8.29	100	24,000	25,000
101	Darjeeling M	73	93	100	10.57	10.57	100	n.a.	31,534
102	Jalpaiguri M	69	101	100	10.08	12.98	100	n.a.	30,350
103	Jangipur M	56	78	87	7.77	8.20	100	n.a.	35,186
104	Katwa M	56	68	100	8.53	8.53	100	22,214	27,065
105	Raniganj M	62	121	63	4.79	n.a.	n.a.	36,000	45,000
	Small States								
	Himachal Pradesh								
106	Shimla M.Corp.	82	111	100	19.55	28.53	100	0	0
	Nagaland								
107	Kohima TC	51	103	100	23.00	36.00	100	21,000	37,500
	Union Territories								
108	Port Blair MCl	75	105	100	14.14	16.64	100	n.a.	9,800
	Others(Smaller than Class II towns)								
	Small States								
	Goa								
109	Panaji MCl	43	57	100	22.63	22.63	100	2,000	2,000
	Sikkim								
110	Gangtok (Greater Gangtok) NTAC	25	106	75	7.25	7.25	75	n.a.	18,000
	Union Territories								
111	Daman MCl	27	35	100	5.60	5.60	100	2,700	3,500
112	Silvassa CT	12	20	100	6.65	6.65	100	3,000	5,000

* Estimated by respective local governments / relevant agencies

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
	Metropolitan Cities									
1	Ahmedabad M.Corp.	364	1273	703	570	1273	100	once daily	Yes	Incineration
2	Bangalore M.Corp.	500	2500	1500	1000	2200	88	once daily	Yes	Incineration
3	Bhopal M.Corp.	320	480	384	96	360	75	once daily	Yes	n.a.
4	Calcutta M.Corp.	513	2500	1375	1125	2100	84	once daily	Yes	n.a.
5	Chennai M.Corp.	573	2500	1700	800	2500	100	once daily	Yes	None
6	Coimbatore M.Corp.	690	670	n.a.	n.a.	670	100	once daily	Yes	Incineration
7	Delhi M.Corp.	500	6000	4800	1200	5500	92	once daily	Yes	Incineration
8	Greater Mumbai M.Corp.	541	6000	3600	2400	6000	100	once daily	Yes	Incineration
9	Hyderabad M.Corp.	504	2100	n.a.	n.a.	1900	90	once daily	Yes	Incineration
10	Indore M.Corp.	375	600	240	360	600	100	twice daily	Yes	Incineration
11	Jaipur M.Corp.	742	1483	n.a.	n.a.	1483	100	once daily	Yes	Incineration
12	Kanpur M.Corp.	520	1300	910	390	1100	85	once daily	No	n.app.
13	Kochi M.Corp.	368	250	n.a.	n.a.	240	96	once daily	No	n.app.
14	Lucknow M.Corp.	500	1250	800	450	875	70	once daily	No	n.app.
15	Ludhiana M.Corp.	600	1200	800	400	875	73	n.a.	No	n.app.
16	Madurai M.Corp.	471	480	335	145	450	94	once daily	Yes	Incineration
17	Nagpur M.Corp.	286	600	400	200	500	83	once daily	Yes	Incineration
18	Pune M.Corp.	522	1200	900	300	900	75	once daily	No	Incineration
19	Surat M.Corp.	414	1035	466	569	960	93	twice daily	Yes	None
20	Vadodara M.Corp.	400	560	n.a.	n.a.	440	79	twice daily	Yes	Incineration
21	Varanasi M.Corp.	500	576	432	144	461	80	twice daily	No	n.app.
22	Visakhapatnam M.Corp.	469	600	300	300	600	100	once daily	Yes	None
	Total-Metropolitan Cities	**500**	**35157**	**19645**	**10449**	**31987**	**91**			

* Estimated by respective local governments / relevant agencies

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
	Class I									
	Andhra Pradesh									
1	Anantapur MCl	440	110	60	50	110	100	once daily	No	n.app.
2	Chittoor M	502	**75**	54	21	70	100	once daily	No	n.app.
3	Cuddapah MCl	506	84	39	45	84	100	once daily	No	n.app.
4	Eluru M	591	146	90	56	146	100	n.a.	No	n.app.
5	Guntur MCl	449	250	190	60	250	100	once daily	No	n.app.
6	Hindupur M	500	70	n.a.	n.a.	70	100	once daily	No	n.app.
7	Kakinada M	492	160	90	70	145	91	twice daily	No	n.app.
8	Kurnool MCl	355	100	56	44	90	90	once daily	No	n.app.
9	Machilipatnam M	350	70	28	42	50	71	once daily	No	n.app.
10	Nandyal MCl	400	60	36	24	60	100	once daily	Yes	n.a.
11	Nellore MCl	413	167	120	47	167	100	once daily	No	n.app.
12	Nizamabad M	498	142	85	57	88	62	twice daily	No	n.app.
13	Ongole MCl	500	90	57	33	90	100	once daily	Yes	n.a.
14	Qutubullapur M	280	70	60	10	70	100	once daily	No	n.app.
15	Rajahmundry M.Corp.	508	193	31	162	193	100	twice daily	No	n.app.
16	Tenali M	529	90	11	79	80	89	twice daily	No	n.app.
17	Tirupati MCl	619	130	85	45	130	100	once daily	No	n.app.
18	Vijaywada M.Corp.	568	475	250	225	465	98	twice daily	Yes	Incineration
19	Warangal M.Corp.	412	280	140	140	230	82	once daily	No	n.app.
	Bihar									
20	Bihar Sharif M	200	50	22	29	50	100	once daily	No	n.app.
21	Chhapra M	480	96	n.a.	n.a.	66	69	twice daily	Yes	Incineration
22	Gaya M.Corp.	200	80	60	20	80	100	twice daily	No	n.app.
23	Katihar M	400	80	n.a.	n.a.	45	56	once daily	No	n.app.
24	Munger M	333	70	n.a.	n.a.	50	71	twice daily	No	n.app.
25	Ranchi M.Corp.	146	102	n.a.	n.a.	34	33	once daily	No	n.app.
	Gujarat									
26	Anand M	57	10	4.0	6	10	100	twice daily	No	n.app.
27	Bharuch M	535	85	44	41	85	100	once daily	No	n.app.
28	Bhavnagar M.Corp.	300	165	95	70	115	70	n.a.	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
29	Bhuj M	339	40	28	12	40	100	once daily	No	n.app.
30	Jamnagar M.Corp.	600	300	150	150	300	100	once daily	No	n.app.
31	Junagadh M	515	85	45	40	75	88	twice daily	No	n.app.
32	Nadiad M	200	60	30	30	60	100	twice daily	No	n.app.
33	Navsari M	288	40	30	10	31	78	twice daily	No	n.app.
34	Porbandar M	204	29	n.a.	n.a.	22	76	once daily	No	n.app.
35	Rajkot M.Corp.	450	450	450	n.a.	425	94	once daily	Yes	None
36	Surendranagar M	207	31	n.a.	n.a.	31	100	once daily	No	n.app.
	Haryana									
37	Ambala MCl	248	35	25	10	30	86	once daily	No	n.app.
38	Faridabad M.Corp.	478	550	492	58	480	87	once daily	No	n.app.
39	Gurgaon MCl	514	90	70	20	80	89	twice daily	No	n.app.
40	Hissar MCl	200	50	32	18	32	64	once daily	No	n.app.
41	Karnal MCl	341	75	50	25	52	69	twice daily	No	n.app.
42	Rohtak MCl	210	51	30	21	28	55	once daily	No	n.app.
	Jammu & Kashmir									
43	Jammu M.Corp.	468	425	n.a.	n.a.	300	71	twice daily	No	n.app.
44	Srinagar M.Corp.	375	300	200	100	200	67	once daily	Yes	Incineration
	Karnataka									
45	Belgaum M.Corp.	266	125	75	50	100	80	once daily	No	n.app.
46	Bellary CMC	202	60	36	24	50	83	once daily	No	n.app.
47	Davangere MCl	198	90	36	54	78	87	twice daily	No	n.app.
48	Gadag-Betigeri CMC	506	75	20	55	60	80	twice daily	No	n.app.
49	Gulbarga M.Corp.	200	90	60	30	76	84	once daily	Yes	n.a.
50	Hubli-Dharwad M.Corp.	376	320	100	220	220	69	once daily	No	n.app.
51	Mandya M	179	25	18	7.0	25	100	twice daily	No	n.app.
52	Mangalore M.Corp.	190	78	46	32	70	90	twice daily	No	n.app.
53	Mysore M.Corp.	195	205	138	67	205	100	twice daily	No	n.app.
54	Shimoga CMC	361	80	35	45	72	89	once daily	No	n.app.
55	Tumkur M	290	87	26	61	84	97	once daily	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
	Kerala									
56	Alappuzha MC	125	25	19	6.3	20	80	once daily	Yes	Incineration
57	Kollam MC	375	60	19	41	58	97	twice daily	Yes	Incineration
58	Kozhikode M.Corp.	446	220	145	75	154	70	twice daily	Yes	Incineration
59	Thalaserry M	299	40	20	20	30	75	once daily	No	n.app.
60	Thiruvananthapuram M.Corp.	513	300	n.a.	n.a.	250	83	once daily	Yes	Incineration
	Madhya Pradesh									
61	Bhind M	160	28	21	7.3	24	86	twice daily	No	n.app.
62	Burhanpur M.Corp.	286	60	n.a.	n.a.	60	100	twice daily	No	n.app.
63	Dewas M.Corp.	250	50	n.a.	n.a.	40	80	once daily	Yes	Incineration
64	Guna M	144	18	12	6.0	18	100	twice daily	No	n.app.
65	Gwalior M.Corp.	400	360	n.a.	n.a.	280	78	once daily	No	n.app.
66	Jabalpur M.Corp.	300	300	145	155	298	99	once daily	No	n.app.
67	Khandwa M	114	20	18	2.0	20	100	once daily	No	n.app.
68	Morena M	400	50	28	22	44	88	twice daily	No	n.app.
69	Murwara-Katni M.Corp.	350	63	33	30	63	100	twice daily	No	n.app.
70	Ratlam M.Corp.	213	50	n.a.	n.a.	35	70	once daily	Yes	n.a.
71	Rewa M.Corp.	267	48	48	n.app.	40	83	twice daily	No	n.app.
72	Satna M.Corp.	250	50	n.a.	n.a.	50	100	twice daily	No	n.app.
73	Shivpuri M	129	18	10	8.0	18	100	twice daily	No	n.app.
	Maharashtra									
74	Amravati M.Corp.	200	100	n.a.	n.a.	100	100	once daily	No	n.app.
75	Aurangabad M.Corp.	392	340	170	170	340	100	thrice daily	No	n.app.
76	Bhusawal M.Cl.	150	30	30	n.a.	30	100	once daily	No	n.app.
77	Chandrapur MCl	502	148	15	133	110	74	once daily	No	n.app.
78	Dhule MCl	106	35	n.a.	n.a.	30	86	once daily	No	n.app.
79	Ichalkaranji MCl	660	165	132	33	150	91	once daily	No	n.app.
80	Jalgaon MCl	550	220	100	120	220	100	once daily	No	n.app.
81	Kolhapur M.Corp.	309	155	n.a.	n.a.	115	74	once daily	No	n.app.
82	Nanded Waghala M.Corp.	312	128	110	18	90	70	twice daily	No	n.app.
83	Nashik M.Corp.	334	280	251	29	280	100	weekly	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
84	Parbhani MCl	309	72	n.a.	n.a.	72	100	thrice daily	No	n.app.
85	Solapur M.Corp.	450	405	243	162	353	87	twice daily	No	n.app.
86	Wardha M	267	40	20	20	40	100	alternate day	No	n.app.
87	Yavatmal MCl	77	10	4.5	5.5	10	100	twice daily	No	n.app.
	Orissa									
88	Bhubaneswar M.Corp.	535	350	n.a.	n.a.	175	50	once daily	No	n.app.
89	Cuttack M.Corp.	568	320	219	101	320	100	once daily	No	n.app.
90	Puri M	401	60	33	27	53	88	once daily	No	n.app.
91	Rourkela M	300	60	28	32	40	67	once daily	No	n.app.
92	Sambalpur M	465	73	n.a.	n.a.	32	44	once daily	No	n.app.
	Punjab									
93	Amritsar M.Corp.	711	600	375	225	510	85	once daily	No	n.app.
94	Bathinda MCl	603	105	60	45	95	90	once daily	No	n.app.
95	Hoshiarpur MCl	228	33	26	6.6	33	100	once daily	No	n.app.
96	Jalandhar M. Corp.	339	250	185	65	236	94	once daily	No	n.app.
97	Moga MCl	243	36	25	11	36	100	once daily	No	n.app.
98	Pathankot MCl	128	25	20	5.3	23	92	once daily	No	n.app.
99	Patiala M.Corp.	244	80	50	30	80	100	once daily	No	n.app.
	Rajasthan									
100	Ajmer MCl	545	300	250	50	250	83	twice daily	No	n.app.
101	Alwar M	333	100	n.a.	n.a.	100	100	once daily	No	n.app.
102	Beawar M	298	42	n.a.	n.a.	42	100	twice daily	No	n.app.
103	Bhilwara M	324	73	29	44	58	79	twice daily	Yes	n.a.
104	Bikaner M	300	180	126	54	180	100	twice daily	No	n.app.
105	Jodhpur M.Corp.	308	308	240	69	308	100	twice daily	Yes	Incineration
106	Kota M.Corp.	280	210	n.a.	n.a.	120	57	once daily	No	n.app.
107	Sriganganagar M	116	26	26	0.1	24	92	twice daily	No	n.app.
	Tamil Nadu									
108	Cuddalore M	401	65	45	20	60	92	once daily	Yes	Incineration
109	Dindigul M	178	38	17	21	17	43	once daily	Yes	Incineration
110	Erode M	518	90	30	60	85	94	once daily	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
111	Kanchipuram M	210	33	26	7.0	19	58	twice daily	Yes	None
112	Kumbakonam M	306	45	15	30	40	89	twice daily	Yes	Incineration
113	Nagercoil M	170	35	28	7.0	30	86	once daily	Yes	Incineration
114	Rajapalaiyam M	359	44	26	18	43	97	once daily	No	n.app.
115	Salem M.Corp.	559	250	160	90	214	86	once daily	Yes	Incineration
116	Thanjavur M	198	43	24	19	35	81	once daily	Yes	Incineration
117	Tiruchirapalli M.Corp.	375	300	255	45	280	93	twice daily	Yes	None
118	Tirunelveli M.Corp.	242	100	60	40	87	87	once daily	No	n.app.
119	Tirunvannamalai M	300	39	24	15	32	83	once daily	No	n.app.
120	Tiruppur M	339	100	51	49	100	100	n.a.	No	n.app.
121	Tuticorin M	115	25	10	15	25	100	once daily	No	n.app.
122	Vellore M	227	40	n.a.	n.a.	35	88	once daily	No	n.app.
	Uttar Pradesh									
123	Agra M.Corp.	500	575	230	345	430	75	once daily	No	n.app.
124	Aligarh M.Corp.	600	360	180	180	275	76	twice daily	No	n.app.
125	Allahabad M.Corp.	300	305	204	101	250	82	twice daily	No	n.app.
126	Bareilly M.Corp.	533	400	152	248	320	80	twice daily	No	n.app.
127	Etawah MB	193	27	24	3.0	27	100	twice daily	No	n.app.
128	Faizabad MB	400	68	45	23	54	79	twice daily	No	n.app.
129	Firozabad MB	640	160	128	32	144	90	twice daily	No	n.app.
130	Ghaziabad M.Corp.	338	300	n.a.	n.a.	300	100	twice daily	No	n.app.
131	Gorakhpur M.Corp.	500	300	225	75	240	80	twice daily	No	n.app.
132	Haldwani-cum-Kathgodam MB	569	80	30	50	80	100	twice daily	No	n.app.
133	Hapur MB	575	115	n.a.	n.a.	70	61	twice daily	No	n.app.
134	Hardwar MB	683	205	n.a.	n.a.	182	89	twice daily	No	n.app.
135	Jhansi MB	355	180	100	80	135	75	twice daily	No	n.app.
136	Mathura MB	425	170	n.a.	n.a.	150	88	once daily	Yes	Incineration
137	Meerut M.Corp.	500	625	n.a.	n.a.	500	80	twice daily	No	n.app.
138	Mirzapur MB	500	105	75	30	86	81	twice daily	No	n.app.
139	Moradabad M.Corp.	448	300	200	100	300	100	thrice daily	No	n.app.
140	Muzaffarnagar MB	498	162	100	62	130	80	twice daily	No	n.app.
141	Rae Bareli MB	500	88	53	35	66	75	twice daily	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
142	Rampur MB	505	160	n.a.	n.a.	120	75	twice daily	No	n.app.
143	Saharanpur MB	500	270	130	140	200	74	twice daily	No	n.app.
144	Sitapur MB	500	75	n.a.	n.a.	70	93	once daily	No	n.app.
145	Unnao MB	99	12	n.a.	n.a.	8	67	once daily	No	n.app.
	West Bengal									
146	Asansol M.Corp.	248	78	52	26	60	77	once daily	No	n.app.
147	Baharampur M	566	81	59	22	81	100	once daily	No	n.app.
148	Balurghat M	250	33	18	15	33	100	once daily	No	n.app.
149	Bankura M	183	28	10	18	26	94	once daily	Yes	None
150	Barasat M	353	53	45	8.0	24	45	thrice daily	No	n.app.
151	Burdwan M	310	100	55	45	75	75	twice daily	No	n.app.
152	Halisahar M	134	20	8.0	12	17	85	once daily	n.a.	n.a.
153	Krishna Nagar M	342	50	25	25	38	76	once daily	No	n.app.
154	Midnapur M	400	63	33	30	53	84	twice daily	No	n.app.
155	North Barrackpur M	338	40	30	10	40	100	once daily	No	n.app.
156	Santipur M	250	33	20	13	33	100	twice weekly	No	n.app.
157	Siliguri M.Corp.	480	240	202	38	150	63	once daily	No	n.app.
	Small States									
	Assam									
158	Guwahati M.Corp.	214	300	180	120	240	80	once daily	Yes	Incineration
159	Jorhat MB	118	20	11	9.0	14	70	once daily	n.a.	n.a.
	Manipur									
160	Imphal MCl	249	61	20	41	38	62	once daily	Yes	None
	Meghalaya									
161	Shillong MB	360	78	51	27	78	100	once daily	No	n.app.
	Tripura									
162	Agartala MCl	400	80	47	33	60	75	twice daily	Yes	n.a.
	Union Territories									
163	Chandigarh M.Corp.	382	325	n.a.	n.a.	280	86	once daily	No	n.app.
164	Pondicherry M	517	150	112	**38**	120	80	twice daily	Yes	Incineration

* Estimated by respective local governments / relevant agencies

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management
C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
	Class II									
	Andhra Pradesh									
1	Anakapalle M	565	65	50	15	55	85	twice daily	No	n.app.
2	Dharmavaram M	100	10	4.0	6.0	9	90	once daily	No	n.app.
3	Gudur MCl	417	30	6.0	24	18	60	twice daily	No	n.app.
4	Kapra M	400	48	29	19	48	100	once daily	No	n.app.
5	Kavali MCl	424	36	23	13	24	67	once daily	No	n.app.
6	Madanapalle M	250	25	15	10	20	80	twice daily	No	n.app.
7	Narasaraopet M	474	45	15	30	42	93	once daily	No	n.app.
8	Rajendra Nagar MCl	100	12	6.0	6.0	12	100	once daily	Yes	None
9	Sangareddy MCl	300	18	5.4	13	18	100	once daily	No	n.app.
10	Srikakulam MCl	400	40	28	12	25	63	once daily	No	n.app.
11	Srikalahasti M	500	35	n.a.	n.a.	30	86	once daily	No	n.app.
12	Suryapet MCl	506	45	17	28	40	89	once daily	No	n.app.
	Bihar									
13	Buxar M	180	12	n.a.	n.a.	12	100	once daily	No	n.app.
14	Deoghar M	250	25	n.a.	n.a.	10	40	once daily	No	n.app.
15	Hajipur M	497	57	n.a.	n.a.	24	42	once daily	No	n.app.
16	Hazaribagh M	504	60	42	18	36	60	once daily	No	n.app.
17	Jehanabad M	175	10	9.5	0.5	10	100	once daily	No	n.app.
18	Madhubani M	338	22	n.a.	n.a.	15	68	twice daily	No	n.app.
19	Mokama M	606	40	30	10	4	10	once daily	No	n.app.
	Gujarat									
20	Amreli M	353	30	n.a.	n.a.	30	100	twice daily	No	n.app.
21	Ankleswar M	100	6	n.a.	n.a.	6	100	once daily	Yes	None
22	Dabhoi M	277	18	n.a.	n.a.	18	100	once daily	No	n.app.
23	Dohad M	51	4	2.5	1.5	4	100	twice daily	No	n.app.
24	Gondal M	100	10	8.0	2.0	10	100	once daily	No	n.app.
25	Jetpur M	400	50	25	25	40	80	once daily	No	n.app.
26	Mahesana M	58	8	n.a.	n.a.	8	100	twice daily	Yes	None
27	Palanpur M	598	70	n.a.	n.a.	40	57	twice weekly	No	n.app.
	Haryana									
28	Jind MCl	211	24	19	5.0	18	75	once daily	No	n.app.
29	Kaithal MCl	159	15	11	4.0	12	80	once daily	No	n.app.
30	Rewari MCl	152	16	16	0	16	100	twice daily	No	n.app.
31	Thanesar MCl	305	31	25	5.5	24	80	once daily	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
	Karnataka									
32	Bagalkot CMC	150	15	9.0	6.0	13	87	twice daily	No	n.app.
33	Chikmagalur CMC	200	20	9.0	11	18	90	once daily	No	n.app.
34	Gokak CMC	132	9	4.0	5.0	7	78	twice daily	Yes	None
35	Hospet CMC	350	40	17	23	31	78	alternate day	No	n.app.
36	Kolar CMC	223	25	12	13	15	60	alternate day	No	n.app.
37	Rabkavi-Banhatti CMC	250	18	13	4.7	12	67	once daily	No	n.app.
38	Ramanagaram CMC	357	25	17	8.0	10	40	alternate day	No	n.app.
	Kerala									
39	Changanessary MC	242	15	7.5	7.5	12	80	once daily	No	n.app.
40	Payyanur M	142	10	6.0	4.0	4	40	once daily	No	n.app.
41	Taliparamba M	200	10	7.0	3.4	3	29	once daily	No	n.app.
42	Thrissur MC	440	40	24	16	35	88	once daily	Yes	Incineration
	Madhya Pradesh									
43	Hoshangabad M	150	15	14	1.0	15	100	twice daily	No	n.app.
44	Itarsi M	143	15	12	3.0	15	100	once daily	No	n.app.
45	Khargone M	75	6	n.a.	n.a.	6	100	twice daily	No	n.app.
46	Mandsaur M	325	40	30	10	26	65	twice daily	No	n.app.
47	Nagda M	200	20	n.a.	n.a.	10	50	twice daily	No	n.app.
48	Neemuch M	80	8	5.0	3.0	8	100	twice daily	No	n.app.
49	Sehore M	300	30	n.a.	n.a.	30	100	once daily	No	n.app.
50	Shahdol M	150	11	5.3	6.0	9	80	once daily	No	n.app.
51	Vidisha M	100	13	9.0	3.5	10	80	twice daily	No	n.app.
	Maharashtra									
52	Amalner MCl	60	6	n.a.	n.a.	6	100	once daily	No	n.app.
53	Ballarpur MCl	165	18	10	8.0	18	100	once daily	Yes	Incineration
54	Bhandara M	158	12	n.a.	n.a.	12	100	twice daily	No	n.app.
55	Kamptee MCl	584	55	35	20	40	72	once daily	No	n.app.
56	Manmad MCl	98	8.5	5.4	3.1	5.4	64	twice daily	No	n.app.
57	Ratnagiri MCl	429	30	22	8.0	22	73	once daily	No	n.app.
58	Satara MCl	300	30	n.a.	n.a.	17	55	once daily	No	n.app.
59	Virar MCl	500	50	40	10	50	100	twice daily	No	n.app.
	Punjab									
60	Ferozepur MCl	543	50	38	12	40	80	twice daily	No	n.app.
61	Kapurthala M	118	10	8.0	2.0	10	100	twice daily	No	n.app.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
62	Mansa MCl	406	27	27	0	27	100	once daily	No	n.app.
63	Phagwara MCl	148	16	13	3.0	14	88	twice daily	No	n.app.
64	Sangrur MCl	285	20	15	5.0	15	75	twice daily	No	n.app.
	Rajasthan									
65	Banswara M	227	25	n.a.	n.a.	25	100	twice daily	No	n.app.
66	Barmer M	298	25	23	2.0	18	72	twice daily	No	n.app.
67	Bundi M	375	30	24	6.0	24	80	once daily	No	n.app.
68	Churu M	343	34	25	9.2	30	87	twice daily	No	n.app.
69	Hanumangarh M	344	43	39	4.0	43	100	once daily	No	n.app.
70	Sawai Madhopur M	45	4	3.0	1.0	4	100	once daily	Yes	n.a.
	Tamil Nadu									
71	Ambur M	187	16	8.0	8.0	13	81	once daily	Yes	n.a.
72	Arakkonam M	205	18	n.a.	n.a.	11	61	once daily	No	n.app.
73	Attur M	203	13	8.0	5.0	10	77	once daily	No	n.app.
74	Cumbum M	76	4	n.a.	n.a.	4	100	once daily	No	n.app.
75	Dharmapuri M	250	17	10	6.7	11	66	twice daily	Yes	Incineration
76	Gudiyatham M	179	17	8.5	8.5	16	94	once daily	No	n.app.
77	Nagapattinam M	267	30	n.a.	n.a.	25	83	once daily	Yes	Incineration
78	Pudukkottai M	204	22	n.a.	n.a.	20	91	once daily	Yes	None
79	Sivakasi M	100	7	4.0	3.0	5	71	once daily	No	n.app.
80	Srivilliputtur M	298	22	13	9.0	20	91	once daily	No	n.app.
81	Tindivanam M	214	15	n.a.	n.a.	12	80	once daily	Yes	None
82	Udhagamandalam M	74	7.4	2.3	5.1	7.4	100	once daily	No	n.app.
	Uttar Pradesh									
83	Auraiya MB	244	22	19	3.3	21	95	twice daily	No	n.app.
84	Balrampur MB	371	26	n.a.	n.a.	20	77	once daily	No	n.app.
85	Basti MB	364	40	n.a.	n.a.	35	88	once daily	No	n.app.
86	Bhadohi MB	600	75	30	45	40	53	twice daily	No	n.app.
87	Chandpur MB	61	4.9	4.8	0.1	4.9	100	twice daily	No	n.app.
88	Etah MB	450	61	43	18	40	66	twice daily	No	n.app.
89	Ghazipur MB	403	39	29	10	27	70	twice daily	Yes	n.a.
90	Gonda MB	298	34	n.a.	n.a.	25	74	twice daily	No	n.app.
91	Lakhimpur MB	450	45	n.a.	n.a.	35	78	twice daily	No	n.app.
92	Lalitpur MB	550	55	50	5.0	55	100	twice daily	Yes	n.a.

Status of Municipal Solid Waste Management

C-2: Solid Waste Generation and Collection, 1999

Sl. No.	City/Town	Solid waste generated		Solid Waste by source (MT/day)		Waste collected (MT/day)	% waste collected to generated	Frequency of solid waste collection	Medical waste collected & disposed	
		gms pc /day	MT /day *	Domestic	Non-domestic				Separately (Yes/No)	Treatment provided
	1	2	3	4	5	6	7	8	9	10
93	Mughalsarai MB	400	64	39	26	48	75	twice daily	No	n.app.
94	Nawabganj-Barabanki MB	111	10	n.a.	n.a.	6	62	once daily	No	n.app.
95	Orai MB	450	77	55	22	29	38	twice daily	No	n.app.
96	Roorkee MB	300	30	18	12	27	90	twice daily	No	n.app.
	West Bengal									
97	Bishnupur M	199	13	11	2.7	13	100	once daily	No	n.app.
98	Chakdaha M	300	27	20	6.7	7	28	twice weekly	No	n.app.
99	Contai M	250	29	22	6.4	9	31	twice daily	Yes	None
100	Cooch Behar M	214	21	10	11	21	100	twice daily	Yes	None
101	Darjeeling M	538	50	15	35	30	60	once daily	No	n.app.
102	Jalpaiguri M	247	25	20	5.3	21	82	once daily	Yes	None
103	Jangipur M	422	33	11	23	18	55	once daily	No	n.app.
104	Katwa M	547	37	14	23	36	97	once daily	Yes	None
105	Raniganj M	446	54	36	18	41	76	once daily	Yes	None
	Small States									
	Himachal Pradesh									
106	Shimla M.Corp.	396	44	19	25	35	80	once daily	No	n.app.
	Nagaland									
107	Kohima TC	219	23	n.a.	n.a.	23	100	n.a.	No	n.app.
	Union Territories									
108	Port Blair MCl	476	50	45	5.0	44	88	once daily	Yes	Incineration
	Others (Smaller than Class II towns)									
	Small States									
	Goa									
109	Panaji MCl	385	22	9.0	13	11	51	twice daily	Yes	Incineration
	Sikkim									
110	Gangtok (Greater Gangtok) NTAC	660	70	30	40	35	50	once daily	No	n.app.
	Union Territories									
111	Daman MCl	314	11	n.a.	n.a.	11	100	twice daily	No	n.app.
112	Silvassa CT	200	4	3.5	0.5	4	100	once daily	No	n.app.
	Total-Class II Towns	**297**	**3079**	**1520**	**869**	**2314**	**75**			
	Grand Total	**433**	**60823**	**32003**	**18130**	**53505**	**88**			

* Estimated by respective local governments / relevant agencies

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
	Metropolitan Cities								
1	Ahmedabad M.Corp.	92	-	1-5	-	867	10	Y	-
2	Bangalore M.Corp.	316	-	1-2	-	2200	15	Y	-
3	Bhopal M.Corp.	51	-	2	-	360	15	Y	-
4	Calcutta M.Corp.	225	-	2-3	-	2100	5	Y	-
5	Chennai M.Corp.	425	-	2-4	-	2500	5	Y	-
6	Coimbatore M.Corp.	68	-	3	-	563	15	N	n.a.
7	Delhi M.Corp.	560	-	3	-	5500	20	Y	-
8	Greater Mumbai M.Corp.	1173	-	1-2	-	6000	15	Y	-
9	Hyderabad M.Corp.	175	-	2-4	-	1885	5	Y	-
10	Indore M.Corp.	n.a.	-	n.a.	-	600	5	Y	-
11	Jaipur M.Corp.	64	-	3	-	1483	10	Y	-
12	Kanpur M.Corp.	103	-	4-5	-	1100	30	Y	-
13	Kochi M.Corp.	43	-	2	-	240	n.a.	N	Private workshop
14	Lucknow M.Corp.	47	-	4-8	-	875	20	Y	-
15	Ludhiana M.Corp.	66	-	2-15	-	875	n.a.	n.a.	n.a.
16	Madurai M.Corp.	64	-	3	-	450	10	N	Private workshop
17	Nagpur M.Corp.	74	-	2-5	-	500	10	Y	-
18	Pune M.Corp.	123	-	2-5	-	900	n.a.	Y	-
19	Surat M.Corp.	124	-	2-4	-	960	20	Y	-
20	Vadodara M.Corp.	47	-	2-7	-	440	10	Y	-
21	Varanasi M.Corp.	40	-	2-5	-	456	5	Y	-
22	Visakhapatnam M.Corp.	91	-	2	-	600	20	Y	-

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
	Class I								
	Andhra Pradesh								
1	Anantapur MCl	7	-	4	-	108	10	N	Private workshop
2	Chittoor M	7	-	6	-	70	60	N	Private workshop
3	Cuddapah MCl	8	-	4-6	-	73	10	N	Private workshop
4	Eluru M	10	50	5	5	146	15	N	Private workshop
5	Guntur MCl	27	20	4	4	250	10	Y	Municipal workshop
6	Hindupur M	4	-	6	-	70	10	N	Private workshop
7	Kakinada M	14	22	4	1-4	142	15	N	Private workshop
8	Kurnool MCl	11	-	3-6	-	90	10	N	Private workshop
9	Machilipatnam M	4	26	4	3	50	20	N	Private workshop
10	Nandyal MCl	4	105	2	2	60	10	N	Private workshop
11	Nellore MCl	29	-	2-4	-	165	12	N	Private workshop
12	Nizamabad M	9	-	4-6	-	88	30	N	Private workshop
13	Ongole MCl	10	-	5-6	-	90	20	N	Private workshop
14	Qutubullapur M	6	-	4	-	69	2	N	State govt. agency
15	Rajahmundry M.Corp.	23	-	5	-	193	15	N	Private workshop
16	Tenali M	5	-	8	-	80	15	N	Private workshop
17	Tirupati MCl	15	-	3-4	-	130	15	N	Private workshop
18	Vijaywada M.Corp.	48	-	2-5	-	465	10	Y	Municipal workshop
19	Warangal M.Corp.	20	130	3	2	177	10	N	Private workshop
	Bihar								
20	Bihar Sharif M	4	n.a.	6	n.a.	50	50	N	Private workshop
21	Chhapra M	6	-	3	-	66	5	N	Private workshop
22	Gaya M.Corp.	9	-	4-6	-	80	70	Y	Private workshop
23	Katihar M	5	n.a.	5	n.a.	45	20	N	Private workshop
24	Munger M	8	-	5	-	50	10	Y	n.a.
25	Ranchi M.Corp.	12	-	6-10	-	34	5	Y	Private workshop
	Gujarat								
26	Anand M	10	-	4	-	10	10	Y	Municipal workshop
27	Bharuch M	16	-	4-10	-	84	20	N	n.a.
28	Bhavnagar M.Corp.	38	-	1-2	-	115	10	Y	Municipal workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
29	Bhuj M	8	16	4	4	40	10	N	Private workshop
30	Jamnagar M.Corp.	23	14	3-5	7	300	10	Y	Municipal workshop
31	Junagadh M	6	-	15	-	75	10	Y	Municipal workshop
32	Nadiad M	9	-	2-4	-	60	15	N	Private workshop
33	Navsari M	6	-	4-7	-	31	20	N	Private workshop
34	Porbandar M	10	-	4	-	22	30	N	Private workshop
35	Rajkot M.Corp.	35	-	4-6	-	425	20	Y	Municipal workshop
36	Surendranagar M	5	-	4	-	30	10	Y	Municipal workshop
	Haryana								
37	Ambala MCl	5	5	5	4	30	20	N	Private workshop
38	Faridabad M.Corp.	39	-	3	-	480	30	Y	Municipal workshop
39	Gurgaon MCl	4	-	3	-	80	10	N	Private workshop
40	Hissar MCl	8	-	4	-	32	50	N	Private workshop
41	Karnal MCl	8	20	4	2	52	25	N	Private workshop
42	Rohtak MCl	10	-	1-3	-	28	10	N	Private workshop
	Jammu & Kashmir								
43	Jammu M.Corp.	21	-	5-6	-	288	10	Y	Municipal workshop
44	Srinagar M.Corp.	33	1500	2-8		200	10	Y	Municipal workshop
	Karnataka								
45	Belgaum M.Corp.	14	-	2	-	100	n.a.	N	Private workshop
46	Bellary CMC	5	-	4	-	50	n.a.	N	Private workshop
47	Davangere MCl	12	-	3	-	77	n.a.	Y	Municipal workshop
48	Gadag-Betigeri CMC	6	-	5	-	60	0	N	Private workshop
49	Gulbarga M.Corp.	11	-	3	-	76	n.a.	N	Private workshop
50	Hubli-Dharwad M.Corp.	27	-	3-5	-	220	10	N	Private workshop
51	Mandya M	5	-	2-3	-	25	n.a.	N	Private workshop
52	Mangalore M.Corp.	10	-	3	-	69	0	N	Private workshop
53	Mysore M.Corp.	28	8	3	4	202	5	N	Private workshop
54	Shimoga CMC	18	-	2-3	-	72	0	N	Private workshop
55	Tumkur M	8	150	4	n.a.	84	10	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
	Kerala								
56	Alappuzha MC	4	-	1-2	-	20	0	N	Private workshop
57	Kollam MC	12	-	1-2	-	58	10	N	Private workshop
58	Kozhikode M.Corp.	22	-	4	-	152	10	N	Private workshop
59	Thalaserry M	5	-	2-3	-	30	20	N	Private workshop
60	Thiruvananthapuram M.Corp.	44	-	1-3	-	250	15	N	Private workshop
	Madhya Pradesh								
61	Bhind M	22	-	2-3	-	24	n.a.	N	Private workshop
62	Burhanpur M.Corp.	8	-	2-5	-	60	10	N	n.a.
63	Dewas M.Corp.	10	-	1-3	-	39	10	N	n.a.
64	Guna M	7	-	2	-	18	20	N	Private workshop
65	Gwalior M.Corp.	32	-	2-4	-	280	5	Y	Municipal workshop
66	Jabalpur M.Corp.	25	-	5-8	-	298	30	N	n.a.
67	Khandwa M	5	-	1-2	-	20	n.a.	N	Private workshop
68	Morena M	6	-	2-3	-	44	10	N	Private workshop
69	Murwara-Katni M.Corp.	5	-	3-5	-	63	20	Y	Municipal workshop
70	Ratlam M.Corp.	4	-	3-6	-	35	n.a.	Y	Municipal workshop
71	Rewa M.Corp.	5	-	4	-	40	20	N	Private workshop
72	Satna M.Corp.	14	-	2-8	-	50	10	Y	Municipal workshop
73	Shivpuri M	4	-	3	-	18	10	N	n.a.
	Maharashtra								
74	Amravati M.Corp.	14	-	4	-	96	n.a.	N	n.a.
75	Aurangabad M.Corp.	27	-	3	2-3	340	n.a.	Y	Municipal workshop
76	Bhusawal M.Cl.	5	-	6	-	30	10	N	Private workshop
77	Chandrapur MCl	14	-	1-3	-	110	2	N	Private workshop
78	Dhule MCl	8	-	1-12	-	30	20	N	Private workshop
79	Ichalkaranji MCl	15	-	5	-	150	n.a.	Y	Municipal workshop
80	Jalgaon MCl	24	-	3-4	-	220	10	N	Private workshop
81	Kolhapur M.Corp.	18	-	2	-	115	20	Y	Municipal workshop
82	Nanded Waghala M.Corp.	13	-	3	-	90	10	N	Private workshop
83	Nashik M.Corp.	89	7	2	4	279	2	Y	Municipal workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
84	Parbhani MCl	8	-	3	-	72	25	N	Private workshop
85	Solapur M.Corp.	26	-	5-6	-	353	5	Y	Municipal workshop
86	Wardha M	6	-	2	-	40	0	N	Private workshop
87	Yavatmal MCl	8	-	1	-	10	10	N	Private workshop
	Orissa								
88	Bhubaneswar M.Corp.	18	-	n.a.	-	n.a	n.a.	N	Private workshop
89	Cuttack M.Corp.	20	-	3-5	-	n.a	3	N	Private workshop
90	Puri M	9	-	4	-	n.a	n.a.	N	Private workshop
91	Rourkela M	6	-	4	-	n.a	n.a.	N	Private workshop
92	Sambalpur M	7	-	3	-	n.a	n.a.	N	Private workshop
	Punjab								
93	Amritsar M.Corp.	74	-	4-7	-	510	2	Y	Municipal workshop
94	Bathinda MCl	10	-	3	-	95	10	N	Private workshop
95	Hoshiarpur MCl	4	-	2-10	-	33	0	N	Private workshop
96	Jalandhar M. Corp.	54	-	2-5	-	236	5	Y	Municipal workshop
97	Moga MCl	7	-	2	-	36	20	N	Private workshop
98	Pathankot MCl	38	-	1-2	-	23	8	N	Private workshop
99	Patiala M.Corp.	36	-	1-2	-	80	0	N	Private workshop
	Rajasthan								
100	Ajmer MCl	28	-	6	-	250	10	N	Private workshop
101	Alwar M	22	-	1-5	-	100	10	Y	Municipal workshop
102	Beawar M	3	-	8	-	42	n.a.	Y	Municipal workshop
103	Bhilwara M	10	-	3	-	58	10	Y	Municipal workshop
104	Bikaner M	13	-	6	-	180	10	Y	Municipal workshop
105	Jodhpur M.Corp.	57	-	2-3	-	308	12	Y	Municipal workshop
106	Kota M.Corp.	30	-	3	-	120	20	N	n.a.
107	Sriganganagar M	9	-	1-2	-	24	5	N	Private workshop
	Tamil Nadu								
108	Cuddalore M	9	-	3	-	59	0	N	Private workshop
109	Dindigul M	11	-	1-2	-	17	10	N	Private workshop
110	Erode M	10	25	3-4	2	85	10	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
111	Kanchipuram M	8	10	3	1	19	15	N	Private workshop
112	Kumbakonam M	13	10	3-4	4	40	n.a.	N	Private workshop
113	Nagercoil M	9	-	2	-	30	0	N	Private workshop
114	Rajapalaiyam M	11	-	2	-	43	20	N	Private workshop
115	Salem M.Corp.	68	-	3	-	214	n.a.	N	Private workshop
116	Thanjavur M	14	-	2	-	34	15	N	Private workshop
117	Tiruchirapalli M.Corp.	46	-	2-4	-	280	10	N	Private workshop
118	Tirunelveli M.Corp.	26	-	3	-	87	20	N	Private workshop
119	Tirunvannamalai M	10	-	2-3	-	32	30	N	Private workshop
120	Tiruppur M	20	-	2-3	-	100	n.a.	Y	Municipal workshop
121	Tuticorin M	14	-	1-2	-	25	20	Y	Municipal workshop
122	Vellore M	12	-	1-2	-	35	25	N	Private workshop
	Uttar Pradesh								
123	Agra M.Corp.	36	-	5-7	-	430	n.a.	Y	Municipal workshop
124	Aligarh M.Corp.	33	-	2-3	-	275	22	Y	Municipal workshop
125	Allahabad M.Corp.	22	-	2-4	-	250	30	Y	Municipal workshop
126	Bareilly M.Corp.	33	-	1-5	-	320	1	Y	Municipal workshop
127	Etawah MB	5	-	4	-	27	28	N	Private workshop
128	Faizabad MB	4	-	5	-	54	50	N	Private workshop
129	Firozabad MB	11	-	3-6	-	144	15	N	Private workshop
130	Ghaziabad M.Corp.	31	-	3-6	-	300	25	N	Private workshop
131	Gorakhpur M.Corp.	29	-	2-4	-	238	10	N	Private workshop
132	Haldwani-cum-Kathgodam MB	4	-	10	-	38	25	N	Private workshop
133	Hapur MB	4	-	5	-	70	10	N	Private workshop
134	Hardwar MB	35	-	1-6	-	182	8	Y	Municipal workshop
135	Jhansi MB	14	-	4-5	-	134	30	Y	Municipal workshop
136	Mathura MB	10	25	2-6	2	150	5	Y	Municipal workshop
137	Meerut M.Corp.	35	-	4-5	-	500	10	Y	Municipal workshop
138	Mirzapur MB	18	105	2-5	n.a	85	10	Y	Municipal workshop
139	Moradabad M.Corp.	17	-	6-7	-	300	1	Y	Municipal workshop
140	Muzaffarnagar MB	10	-	3-6	-	130	5	N	Private workshop
141	Rae Bareli MB	4	-	6	-	66	5	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
142	Rampur MB	20	-	6	-	120	2	Y	Municipal workshop
143	Saharanpur MB	27	-	2	-	200	30	N	Private workshop
144	Sitapur MB	17	-	2-4	-	70	10	N	Private workshop
145	Unnao MB	2	-	4	-	8	50	N	Private workshop
	West Bengal								
146	Asansol M.Corp.	23	-	3	-	60	n.a.	N	n.a.
147	Baharampur M	13	-	3	-	81	2	Y	Municipal workshop
148	Balurghat M	3	-	3-5	-	33	10	N	Private workshop
149	Bankura M	6	20	1	1	26	n.a.	Y	Municipal workshop
150	Barasat M	5	-	3	-	24	30	N	Private workshop
151	Burdwan M	8	-	2-4	-	75	15	Y	Municipal workshop
152	Halisahar M	3	-	3	-	17	n.a.	N	Private workshop
153	Krishna Nagar M	5	-	3-4	-	37	30	Y	Municipal workshop
154	Midnapur M	5	-	2-5	-	53	15	N	Private workshop
155	North Barrackpur M	6	-	3	-	40	n.a.	N	Private workshop
156	Santipur M	6	-	2-4	-	33	1	Y	Municipal workshop
157	Siliguri M.Corp.	26	-	3	-	150	n.a.	N	n.a.
	Small States								
	Assam								
158	Guwahati M.Corp.	Privatised	-	-	-	240	n.app	N	Private workshop
159	Jorhat MB	5	-	3	-	14	n.a.	N	Private workshop
	Manipur								
160	Imphal MCl	10	-	2-4	-	38	70	Y	Municipal workshop
	Meghalaya								
161	Shillong MB	10	-	1	-	78	20	N	Private workshop
	Tripura								
162	Agartala MCl	12	-	2-4	-	60	20	n.a.	n.a.
	Union Territories								
163	Chandigarh M.Corp.	45	-	2-4	-	280	5	N	Private workshop
164	Pondicherry M	18	-	2-4	-	114	20	Y	Municipal workshop

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
	Class II								
	Andhra Pradesh								
1	Anakapalle M	13	-	1-3	-	55	25	N	Private workshop
2	Dharmavaram M	2	-	3	-	9	0	N	Private workshop
3	Gudur MCl	3	-	5	-	18	30	N	Private workshop
4	Kapra M	9	-	4-6	-	45	2	N	Private workshop
5	Kavali MCl	3	-	4	-	24	30	N	Private workshop
6	Madanapalle M	6	-	1-2	-	20	n.a.	N	Private workshop
7	Narasaraopet M	7	9	1-3	5	42	15	N	Private workshop
8	Rajendra Nagar MCl	3	-	2-3	-	9	20	N	Private workshop
9	Sangareddy MCl	5	-	2-3	-	14	20	N	Private workshop
10	Srikakulam MCl	5	16	4	3	25	n.a.	N	Private workshop
11	Srikalahasti M	3	-	6	-	24	0	N	Private workshop
12	Suryapet MCl	4	-	5	-	30	25	N	Private workshop
	Bihar								
13	Buxar M	2	-	2	-	12	25	N	Private workshop
14	Deoghar M	1	n.a.	6	n.a.	10	10	N	Private workshop
15	Hajipur M	3	-	2	-	24	5	N	Private workshop
16	Hazaribagh M	6	-	3	-	36	25	N	Private workshop
17	Jehanabad M	1	-	4	-	10	30	N	Private workshop
18	Madhubani M	4	-	4	-	15	10	N	Private workshop
19	Mokama M	1	-	4	-	4	n.a.	N	Private workshop
	Gujarat								
20	Amreli M	4	-	7	-	30	15	Y	Municipal workshop
21	Ankleswar M	3	-	2	-	6	5	N	n.a.
22	Dabhoi M	1	-	6	-	18	0	N	Municipal Mechanic
23	Dohad M	4	-	1-2	-	4	10	N	Private workshop
24	Gondal M	9	27	2	2	10	0	Y	Municipal workshop
25	Jetpur M	3	24	8	7	40	0	Y	Municipal workshop
26	Mahesana M	5	-	1-2	-	8	10	Y	Municipal workshop
27	Palanpur M	5	-	3	-	40	10	Y	Municipal workshop
	Haryana								
28	Jind MCl	3	na	4	-	18	10	N	Private workshop
29	Kaithal MCl	4	-	3	-	12	20	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
30	Rewari MCl	4	-	12	-	16	10	N	Private workshop
31	Thanesar MCl	5	3	1-3	3	24	10	N	Private workshop
	Karnataka								
32	Bagalkot CMC	4	-	2	-	13	n.a.	N	Private workshop
33	Chikmagalur CMC	4	-	2	-	18	0	N	Private workshop
34	Gokak CMC	4	-	1-2	-	7	0	N	Private workshop
35	Hospet CMC	5	-	5	-	31	n.a.	N	Private workshop
36	Kolar CMC	5	-	3-4	-	15	30	N	Private workshop
37	Rabkavi-Banhatti CMC	Privatised	-	-	-	Auctioned	n.app	N	Private workshop
38	Ramanagaram CMC	4	-	2-3	-	10	50	N	Private workshop
	Kerala								
39	Changanessary MC	n.a.	n.a.	n.a.	n.a.	12	n.a.	n.a.	n.a.
40	Payyanur M	1	-	2	-	4	0	N	Private workshop
41	Taliparamba M	1	-	1	-	3	0	N	Private workshop
42	Thrissur MC	15	-	1-2	-	35	0	N	Private workshop
	Madhya Pradesh								
43	Hoshangabad M	2	-	5	-	15	50	N	Private workshop
44	Itarsi M	6	-	1-2	-	15	30	Y	Municipal workshop
45	Khargone M	3	-	2	-	6	n.a.	N	n.a.
46	Mandsaur M	4	-	2	-	26	25	Y	Municipal workshop
47	Nagda M	2	-	1-3	-	10	n.a.	N	Private workshop
48	Neemuch M	6	-	2	-	8	n.a.	Y	Municipal workshop
49	Sehore M	4	-	4	-	30	25	N	Private workshop
50	Shahdol M	4	-	3	-	9	20	N	Private workshop
51	Vidisha M	5	-	4	-	10	10	N	Private workshop
	Maharashtra								
52	Amalner MCl	4	-	2-3	-	6	n.a.	N	Private workshop
53	Ballarpur MCl	5	-	1-2	-	18	10	N	n.a.
54	Bhandara M	5	-	1-2	-	12	10	N	Private workshop
55	Kamptee MCl	3	-	10	-	40	25	N	Private workshop
56	Manmad MCl	3	-	2-10	-	5	2	N	Private workshop
57	Ratnagiri MCl	4	-	2	-	22	10	Y	Municipal workshop
58	Satara MCl	3	-	3	-	17	0	Y	Municipal workshop
59	Virar MCl	9	-	2	-	50	0	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
	Punjab								
60	Ferozepur MCl	5	-	4	-	40	20	N	Private workshop
61	Kapurthala M	4	-	3	-	10	n.a.	N	Private workshop
62	Mansa MCl	3	-	6	-	27	n.a.	N	Private workshop
63	Phagwara MCl	5	-	2	-	14	0	N	Private workshop
64	Sangrur MCl	3	-	2	-	15	25	N	Private workshop
	Rajasthan								
65	Banswara M	5	-	n.a.	-	25	n.a.	Y	Municipal workshop
66	Barmer M	6	-	1-3	-	18	30	N	Private workshop
67	Bundi M	3	-	4	-	24	0	Y	Municipal workshop
68	Churu M	4	15	2	2	30	10	N	Private workshop
69	Hanumangarh M	8	-	4	-	43	4	N	Private workshop
70	Sawai Madhopur M	4	-	1	-	4	25	N	Private workshop
	Tamil Nadu								
71	Ambur M	5	12	3	3	13	20	Y	Municipal workshop
72	Arakkonam M	5	6	1	3	11	0	N	Private workshop
73	Attur M	4	-	2	-	10	10	N	Private workshop
74	Cumbum M	3	13	2	2	4	15	N	Private workshop
75	Dharmapuri M	2	19	2	1	11	30	N	Private workshop
76	Gudiyatham M	2	-	3	-	16	10	N	Private workshop
77	Nagapattinam M	4	-	4	-	25	0	N	Private workshop
78	Pudukkottai M	7	-	2	-	20	10	N	Private workshop
79	Sivakasi M	9	-	1	-	5	25	N	Private workshop
80	Srivilliputtur M	4	-	2	-	20	25	N	Private workshop
81	Tindivanam M	5	-	2	-	12	15	N	Private workshop
82	Udhagamandalam M	7	-	2	-	7	30	N	Private workshop
	Uttar Pradesh								
83	Auraiya MB	2	-	7	-	21	10	N	Private workshop
84	Balrampur MB	3	-	2	-	20	10	N	Private workshop
85	Basti MB	5	-	2	-	35	20	N	Private workshop
86	Bhadohi MB	2	20	8	5	40	5	N	Private workshop
87	Chandpur MB	2	14	3	2	5	10	N	Private workshop
88	Etah MB	3	-	4-8	-	40	25	N	Private workshop
89	Ghazipur MB	4	-	3	-	27	10	N	Private workshop
90	Gonda MB	3	-	3	-	25	10	N	Private workshop

Status of Municipal Solid Waste Management

C-3: Transportation of Solid Waste, 1999

Sl. No.	City/Town	No. of vehicles used for transportation		Average trips per vehicle per day		Approx. waste (MT) transported daily	% of vehicles usually under repair	Vehicle maintenance workshop	
		Motorized	Non- motorized	Motorized	Non- motorized			Yes / No	Place
	1	2	3	4	5	6	7	8	9
91	Lakhimpur MB	3	-	2-6	-	35	10	N	Private workshop
92	Lalitpur MB	5	-	2-3	-	54	5	N	Private workshop
93	Mughalsarai MB	5	-	2-3	-	48	5	N	Private workshop
94	Nawabganj-Barabanki MB	3	-	2	-	6	35	N	Private workshop
95	Orai MB	3	50	5	8	29	30	N	Private workshop
96	Roorkee MB	3	-	3	-	27	20	N	Private workshop
	West Bengal								
97	Bishnupur M	2	30	2	1	13	25	N	Private workshop
98	Chakdaha M	1	8	2	4	7	3	N	Private workshop
99	Contai M	9	-	1-2	-	9	22	N	n.a.
100	Cooch Behar M	7	20	2-3	2	21	60	Y	Municipal workshop
101	Darjeeling M	n.a.	-	3	-	30	25	Y	Municipal workshop
102	Jalpaiguri M	5	-	1-3	-	20	20	N	Private workshop
103	Jangipur M	2	-	3	-	18	n.a.	N	Private workshop
104	Katwa M	6	-	3	-	36	n.a.	Y	Municipal workshop
105	Raniganj M	7	-	3	-	41	33	N	Private workshop
	Small States								
	Himachal Pradesh								
106	Shimla M.Corp.	8	-	3	-	35	2	N	Private workshop
	Nagaland								
107	Kohima TC	4	-	2-4	-	22	n.a.	N	Private workshop
	Union Territories								
108	Port Blair MCl	8	-	2-3	-	44	15	Y	Municipal workshop
	Others(Smaller than Class II towns)								
	Small States								
	Goa								
109	Panaji MCl	8	-	2	-	11	10	Y	Municipal workshop
	Sikkim								
110	Gangtok (Greater Gangtok) NTAC	7	-	1	-	35	n.a.	Y	Municipal workshop
	Union Territories								
111	Daman MCl	5	-	1-2	-	11	10	N	Private workshop
112	Silvassa CT	2	-	2	-	4	0	N	Private workshop

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Metropolitan Cities					
1	Ahmedabad M.Corp.	JCB	41	n.a.	2-3	563
		Truck	3		7	19
		Tipper	20		2-3	126
		Dumper	27		1-5	143
		Compact Machine	1		3	15
		Total				**867**
2	Bangalore M.Corp.	Tippers	90	5	1	400
		Truck	226	4	2	1800
		Total				**2200**
3	Bhopal M.Corp.	Truck	23	4	2	161
		Compactor	4	5	2	40
		Dumper	9	3	2	45
		Tractor Trolley	11	3	2	66
		Tipper	4	4	2	28
		Others*	10			20
		Total				**360**
4	Calcutta M.Corp.	Truck	163	n.a.		
		Dumper	52			
		Tractor Trolley/Trailer	10			
		Total				**2100**
5	Chennai M.Corp.	Truck	230	n.a.	2	n.a.
		Truck	120		3	
		Autos	75		4	
		Total				**2500**
6	Coimbatore M.Corp.	Truck	24	n.a.	3	n.a.
		Tractor Trolley	2		3	
		Tippers	26		3	
		JCB	16		3	
		Dumper	16		3	
		Total				**670**
7	Delhi M.Corp.	Tractor Trolley	2	3	3	15
		Tipper truck	558	4	3	5485
		Total				**5500**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
8	Greater Mumbai M.Corp.	Mobile compactors	146	8	1	1168
		Skip vehicles	123	3	1	308
		Dumpers	82	4	1	328
		Dumpers (private)	606	4	1	2424
		Others *	216	n.a.	n.a.	1772
		Total				**6000**
9	Hyderabad M.Corp.	Dumper	45	3	5	563
		Tipper	90	4	3	945
		Large compactors	12	8	3	288
		Small compactors	12	3	2	60
		Power tiller	16	1	2	32
		Total				**1888**
10	Indore M.Corp.	Tippers	n.a.	n.a.	3	n.a.
		Dumper			n.a.	
		Total				**600**
11	Jaipur M.Corp.	Dumpers	12	4	3	144
		Canters	52	4	3	624
		JCB	4	n.a.	n.a.	n.a.
		Total				**768**
12	Kanpur M.Corp.	Tippers	40	5	3	600
		Truck	28	3	3	252
		Tractor Trolley	35	2	3-4	250
		Total				**1102**
13	Kochi M.Corp.	Tractor Trolley	11	4	2	77
		Truck	6	6	2	72
		Tippers	2	7	3	42
		Dumper	12	1	2	24
		Auto-trailler	9	0.5	2	9
		Side load lorry & JCB	3	5	n.a.	30
		Total				**254**
14	Lucknow M.Corp.	Tippers	30	4	5	600
		Refuse Collector	5	5	8	200
		Refuse collector	1	5	10	50
		Total				**850**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
15	Ludhiana M.Corp.	Tippers	27	5	5	608
		Dumper placer	25	1.5	4	150
		Tractor Trolley	9	1.5	2	27
		H. Tugger	4	1.5	15	90
		Total				**875**
16	Madurai M.Corp.	Truck	11	3	3	99
		Tractor Trolley/Trailer	4	3	3	30
		Tippers	13	n.a.	3	60
		Mini-Truck	4	1.5	3	18
		Truck (hired)	27	3	3	243
		Total				**450**
17	Nagpur M.Corp.	Truck	30	5	2	300
		Tippers	6	3	3	54
		Truck (hired)	20	3	3	144
		Tractor Trolley	2	0.5	2	2
		Total				**500**
18	Pune M.Corp.	Dumper placer	70	1.5	4	420
		Tippers	52	3	3	460
		Compactor	1	10	2	20
		Total				**900**
19	Surat M.Corp.	Dumper trucks	38	6	2	456
		Dumper placer	57	2	2	228
		Tractor Trailer	28	3	3	252
		Tipper	1	6	4	24
		Total				**960**
20	Vadodara M.Corp.	Dumper placer	22	1.5	7	230
		Tippers	15	5	2	150
		Pick-up van	10	3	2	60
		Total				**440**
21	Varanasi M.Corp.	Tipper truck	12	5	3	180
		Tractor Trolley	16	3	5	240
		Dumper placer	4	1.5	2	12
		JCB	3	2	n.a.	24
		Total				**456**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
22	Visakhapatnam M.Corp.	Van	33	3	2	198
		Tractors	27	3	2	135
		Tipper	15	6	2	180
		Mini-Truck	2	4	2	16
		Truck	1	6	2	12
		Dumper	12	2	n.a.	48
		Compactor	1	6	2	12
		Total				**601**

Note : Data for average waste transported was furnished by the respective urban local bodies. The number of vehicles, multiplied by the average capacity and number of trips may not addup to the waste transported.

"Others" include stationary compactors, tempo private, dumpers private, bulk refuse carrier

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999

Status of Municipal Solid Waste Management
C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Class I					
	Andhra Pradesh					
1	Anantapur MCl	Tractor	4	3	4	48
		Tipper	3	5	4	60
		Total				**108**
2	Chittoor M	Tractor	2	4	6	40
		Truck (privatised	2	3	6	30
		Total				**70**
3	Cuddapah MCl	Tractor (private)	7	1.5	6	63
		Tractor (own)	1	3	4	10
		Total				**73**
4	Eluru M	Tractor	10	2	5	100
		Bullock Carts	50	0.2	5	46
		Total				**146**
5	Guntur MCl	Truck	3	4	4	48
		Tractor	24	2	4	192
		Rickshaw	20	0.1	4	10
		Total				**250**
6	Hindupur M	Tractor	4	3	6	70
		Total				**70**
7	Kakinada M	Tractor	14	2	4	112
		Others	12	3	1	30
		Total				**142**
8	Kurnool MCl	Tipper	1	2	3	n.a.
		Tractor	10	1.5	6	
		Total				**90**
9	Machilipatnam M	Tractor	4	2	4	31
		Bullock Carts	26	0.3	3	20
		Total				**50**
10	Nandyal MCl	Wheel barrow	104	0.3	2	52
		Tractor	4	1	2	8
		Total				**60**
11	Nellore MCl	Truck	1	5	2	9
		Tractor	26	1.5	4	156
		Total				**165**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
12	Nizamabad M	Tractor	4	3	5	60
		Truck	1	7	4	28
		Total				**88**
13	Ongole MCl	Tractor	5	3	6	90
		Total				**90**
14	Qutubullapur M	Truck	5	3	4	60
		Tractor Trolley	1	3	3	9
		Total				**69**
15	Rajahmundry M.Corp.	Tractor	19	2	5	193
						193
16	Tenali M	Tractor	5	2	8	80
		Total				**80**
17	Tirupati MCl	Truck	1	4	3	12
		Tractor	6	2	4	54
		Tractor (hired)	8	2	4	64
		Total				**130**
18	Vijaywada M.Corp.	Van	13	3	5	195
		Tipper	20	3	2	120
		Tractor	15	2	5	150
		Total				**465**
19	Warangal M.Corp.	Tractor	19	3	3	171
		JCB	1	3	2	6
		Total				**177**
	Bihar					
20	Bihar Sharif M	Tractor	4	1	6	24
		Handcarts	n.a.	n.a.	n.a.	26
		Total				**50**
21	Chhapra M	Tractor	6	4	3	72
		Total				**72**
22	Gaya M.Corp.	Loader	1	2	6	12
		Dumper	2	1.5	4	12
		Tractor	7	2	4	56
		Total				**80**
23	Katihar M	Tractor	5	1.5	5	38
		Handcarts	n.a.	n.a.	n.a.	8
		Total				**45**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
24	Munger M	Tractor	7	1.5	5	53
		Total				**53**
25	Ranchi M.Corp.	Tractor	11	n.a.	6	n.a.
		Dumper placer	1		10	
		Total				**34**
	Gujarat					
26	Anand M	Wheel barrow	13	n.a.	4	3
		Truck	2	n.a.	4	4
		Tractor Trolley	1	1.5	2	3
		Total				**10**
27	Bharuch M	Tractor	1	1	4	4
		Truck	1	5	4	20
		Dumper	3	3	4	30
		Tempo	6	0.5	10	30
		Total				**84**
28	Bhavnagar M.Corp.	Refuse Collector	4	7	1	28
		Truck	2	5	1	10
		Tractor Trolley	32	1.2	2	77
		Total				**115**
29	Bhuj M	Tractor Trolley	4	1.5	4	24
		Bullock Carts	3	n.a.	4	2
		Tractor(Hired)	4	1.5	2	12
		Donkey cart (Hired)	13	n.a.	4	2
		Total				**40**
30	Jamnagar M.Corp.	Tractor	17	3	3	153
		Container Carrier	3	3	5	45
		Rickshaw	14	1.1	7	105
		Total				**303**
31	Junagadh M	Tractor	5	1	15	75
		Total				**75**
32	Nadiad M	Truck	2	n.a.	n.a.	29
		Tractor Trolley	2	1	2	4
		Tippers	3	2	4	24
		Rickshaw	2	0.5	3	3
		Total				**60**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
33	Navsari M	Tippers	1	2	6	12
		Tractor	3	1.5	4	18
		Tricycle	5	n.a.	4	1
		Total				**31**
34	Porbandar M	Tractor	6	n.a.	4	11
		Truck	4		4	11
		Total				**22**
35	Rajkot M.Corp.	Truck	16	3	6	240
		Tippers	8	4	4	128
		Others (Geep)	10	1.5	4	60
		Total				**428**
36	Surendranagar M	Tractor	5	1.5	4	30
		Total				**30**
	Haryana					
37	Ambala MCl	Tractor Trolley	5	1	5	25
		Carts	5	0.05	20	5
		Total				**30**
38	Faridabad M.Corp.	Refuse Collector	3	7	3	63
		Truck	3	3	3	27
		Dumper	3	2	3	18
		Tractor Trolley	30	n.a.	n.a.	372
		Total				**480**
39	Gurgaon MCl	Refuse Collector	1	15	3	45
		Tractor Trolley	3	2	3	18
		Loader	2	n.a.	n.a.	17
		Total				**80**
40	Hissar MCl	Tractor Trolley	8	1	4	32
		Total				**32**
41	Karnal MCl	Tractor	8	1	4	32
		Rickshaw	20	0.1	10	20
		Total				**52**
42	Rohtak MCl	Truck	2	2	3	12
		Tractor Trolley	8	2	1	16
		Total				**28**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Jammu & Kashmir					
43	Jammu M.Corp.	Tractor	12	3	5	180
		Trolley	9	2	6	108
		Total				**288**
44	Srinagar M.Corp	Trippers/Trucks	18	0.5	3	27
		Dumper Placer	12	1.5	8	144
		Tractor Trolley	2	6	2	24
		Compacter	1	16	2	32
		Total				**227**
	Karnataka					
45	Belgaum M.Corp.	Tipper (Big)	4	6	2	44
		Truck	10	3	2	56
		Total				**100**
46	Bellary CMC	Truck	5	3	4	50
		Total				**50**
47	Davangere MCl	Tractor	7	1.5	3	32
		Truck	5	3	3	45
		Total				**77**
48	Gadag-Betigeri CMC	Tractor Trolley	6	2	5	60
		Total				**60**
49	Gulbarga M.Corp.	Truck	7	3	3	53
		Tractor	4	2	3	24
		Total				**77**
50	Hubli-Dharwad M.Corp.	Truck	19	3	3	171
		Tractor Trolley	8	1.3	5	50
		Total				**221**
51	Mandya M	Tractor	3	2	3	18
		Truck	2	2	2	8
		Total				**26**
52	Mangalore M.Corp.	Truck	6	3	3	45
		Tractor	3	2	3	18
		Mini-Truck	1	2	3	6
		Total				**69**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
53	Mysore M.Corp.	Truck	16	3	3	120
		Tractor	7	2	3	42
		Mini-Truck	5	2	3	30
		Carts	8	0.3	5	10
		Total				**202**
54	Shimoga CMC	Tractor	11	n.a.	3	41
		Truck	3	3	3	27
		Power tiller	4	1.5	2	12
		Total				**80**
55	Tumkur M	Tractor	7	3	4	84
		Total				**84**
	Kerala					
56	Alappuzha MC	Tippers	2	2	1	4
		Truck	2	4	2	16
		Total				**20**
57	Kollam MC	Truck	3	5	1	15
		Tractor	9	3	2	45
		Total				**60**
58	Kozhikode M.Corp.	Truck	2	3	4	24
		Excavator	2	2	4	16
		Tractor	14	2	4	112
		Total				**152**
5	Thalaserry M	Tractor	2	3	3	15
		Tiller	2	1.5	3	9
		Truck	1	3	2	6
		Total				**30**
60	Thiruvananthapuram M.Corp.	Truck	16	5	2	160
		Tractor	8	3	3	60
		Truck	20	1.5	1	30
		Total				**250**
	Madhya Pradesh					
61	Bhind M	Tipper	1	4	3	12
		Tractor trolley	5	1	2	10
		Wheel barrow	6	0.2	2	2
		Total				**24**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
62	Burhanpur M.Corp.	Truck	2	3	5	25
		Tractor trolley	4	3	3	30
		Auto	2	0.5	2	2
		Total				**57**
63	Dewas M.Corp.	Tractor trolley	1	2	3	6
		Truck	3	3	3	27
		Dumper	6	1	1	6
		Total				**39**
64	Guna M	Tractor trolley	4	1	2	8
		Dumper	3	1.5	2	9
		Total				**17**
65	Gwalior M.Corp.	Truck	7	5	4	140
		Container	2	2	4	16
		Tractor	20	1.5	3	90
		Refuse Collector	2	8	2	32
		Tipper	1	1	4	4
		Total				**282**
66	Jabalpur M.Corp.	Tractor	13	2	5	130
		Truck	1	4	2	7
		Hydraulic Truck	5	3	3	45
		Mini Dumper	4	3	5	50
		Dumper	2	4	8	56
		Largea truck	1	5		10
		Total				**298**
67	Khandwa M	Tractor	3	2	1	6
		Truck	1	3	2	6
		Dumper	1	4	2	8
		Total				**20**
68	Morena M	Dumper	2	5	2	20
		Tractor trolley	4	2	3	24
		Total				**44**
69	Murwara-Katni M.Corp.	Truck	3	3	4	36
		Dumper	1	4	3	12
		Tractor	1	3	5	15
		Total				**63**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
70	Ratlam M.Corp.	Truck	2	n.a.	6	n.a.
		Tractor trolley	2		3	
		Total				**35**
71	Rewa M.Corp.	Tractor trolley	5	2	4	40
		Total				**40**
72	Satna M.Corp.	Dumper	2	8	2	n.a.
		Tractor	11	n.a.	4	
		Truck	1		2	
		Total				**50**
73	Shivpuri M	Tractor trolley	3	1.2	n.a.	
		Dumper	1	2		
		Total				18
	Maharashtra					
74	Amravati M.Corp.	Truck	12	2	4	96
		Total				**96**
75	Aurangabad M.Corp.	Truck	14	5	3	210
		Tippers	10	3	3	90
		Rickshaw	4	0.05	10	2
		Matador	3	3	3	27
		Total				**329**
76	Bhusawal M.Cl.	Tractor Trolley	5	1	6	30
		Total				**30**
77	Chandrapur MCl	Truck	6	3	3	45
		Tractor	3	3	3	23
		Truck (large)	1	4	1	4
		Truck (hired)	4	4	3	42
		Total				**114**
78	Dhule MCl	Truck	5	2	1	10
		Hydraulic truck	1	1	12	12
		Tractor	1	2	2	4
		Dumper	1	3	2	6
		Total				**32**
79	Ichalkaranji MCl	Tractor Trolley	15	2	5	150
		Total				**150**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
80	Jalgaon MCl	Tractor	16	3	4	160
		Dumper	6	3	3	54
		Total				**214**
81	Kolhapur M.Corp.	Truck	14	3	2	84
		Refuse Collector	2	8	2	32
		Total				**116**
82	Nanded Waghala M.Corp.	Truck	1	3	3	9
		Mini-truck	6	2	3	36
		Tipper	1	3	3	9
		Tempo	1	1	3	3
		Tractor Trolley	4	2	3	24
		Total				**81**
83	Nashik M.Corp.	Truck	6	2	2	24
		Tempo	37	1.5	2	111
		Truck	5	1.5	2	15
		Tractor Trolley	38	1.5	2	114
		5 wheeler	5	0.1		15
		Total				**279**
84	Parbhani MCl	Tempo	2	3	3	18
		Tractor Trolley	6	3	3	54
		Total				**72**
85	Solapur M.Corp.	Truck	14	4	5	245
		Tempo	12	1.5	6	108
		Total				**353**
86	Wardha M	Truck	4	4	2	32
		Tractor Trolley	2	2	2	8
		Total				**40**
87	Yavatmal MCl	Tractor	4	1	1	4
		Truck	3	2	1	6
		Total				**10**
	Orissa					
88	Bhubaneswar M.Corp.	Truck	10	2	n.a.	
		Tractor Trolley	8	n.a.		
		Total				**n.a.**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
89	Cuttack M.Corp.	Truck	6	n.a.	3	n.a.
		Tractor Trolley	14		n.a.	
		Total				**n.a.**
90	Puri M	Truck	2	n.a.	n.a.	n.a.
		Tractor Trolley	7		4	
		Total				**n.a.**
91	Rourkela M	Truck	4	n.a.	4	n.a.
		Tractor Trolley	2		n.a.	
		Total				**n.a.**
92	Sambalpur M	Truck	2	1.3	3	n.a.
		Tractor Trolley	4	n.a.	n.a.	
		Dumper	1			
		Total				**8**
	Punjab					
93	Amritsar M.Corp.	Tractor Trolley	56	3	2	336
		Dumper	15	4	2	120
		Tippers	3	10	2	60
		Total				**516**
94	Bathinda MCl	Tractor Trolley	8	3	3	72
		Dumper	2	5	3	27
		Total				**99**
95	Hoshiarpur MCl	Truck	1	5	2	10
		Tractor Trolley	1	1	3	3
		Dumper	2	1	10	20
		Total				**33**
96	Jalandhar M. Corp.	Tippers	11	4	3	132
		Tractor	2	2	4	16
		Dumper	8	1	5	40
		Three wheeler	30	0.2	4	18
		Refuse Collector	3	5	2	30
		Total				**236**
97	Moga MCl	Truck	2	4	2	16
		Tractor Trolley	5	2	2	20
		Total				**36**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
98	Pathankot MCl	Auto rickshaw	6	0.4	2	4
		Tractor Trolley	2	1.2	2	5
		Dumper	30	0.5	1	15
		Total				**24**
99	Patiala M.Corp.	Tractor Trolley	13	1	2	26
		Truck	3	4	2	24
		Container	20	1.5	1	30
		Total				80
	Rajasthan					
100	Ajmer MCl	Tractor Trolley	17	3	6	255
		Total				**255**
101	Alwar M	Tractor Trolley	18	1	5	90
		Tempo	2	0.3	5	3
		Dumper	2	5	1	9
		Total				**102**
102	Beawar M	Tractor Trolley	3	1.8	8	42
		Total				**42**
103	Bhilwara M	Dumper	5	3	3	45
		Tractor Trolley	5	1	3	15
		Total				**60**
104	Bikaner M	Tractor	9	1.1	6	60
		Dumper	4	5	6	120
		Total				**180**
105	Jodhpur M.Corp.	Dumper	17	2	2	68
		Tractor	40	2	3	240
		Total				**308**
106	Kota M.Corp.	Dumper	8	1.5	3	36
		Tractor Trolley	19	1.5	3	86
		Total				**122**
107	Sriganganagar M	Tractor Trolley	6	2	1	12
		Truck	3	2	2	12
		Total				**24**
	Tamil Nadu					

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
108	Cuddalore M	Truck	2	3	3	15
		Tractor	1	2	4	8
		Mini-Truck	6	2	3	36
		Total				**59**
109	Dindigul M	Truck	1	3	2	5
		Mini-Truck	5	1.5	1	8
		Tractor	2	1	1	2
		Power tiller	2	1	1	2
		Total				**17**
110	Erode M	Truck	3	2	3	18
		Mini-Truck	5	1.5	4	30
		Tractor	1	2	4	8
		Power tiller	1	1	4	4
		Bullock Carts	25	0.5	2	25
		Total				**85**
111	Kanchipuram M	Truck	6	n.a.	1	12
		Power Tiller	2	1	3	6
		Total				**18**
112	Kumbakonam M	Truck	1	3	3	9
		Mini-Truck	10	1	3	30
		Total				**39**
113	Nagercoil M	Truck	3	3	2	15
		Power tiller	2	1	2	4
		Truck	4	1.5	2	12
		Total				**31**
114	Rajapalaiyam M	Truck	3	2	2	12
		Tractor	8	2	2	32
		Total				44
115	Salem M.Corp.	Tractor	40	1.5	2	120
		Truck	6	4	2	48
		Mini-Truck	4	2	2	16
		Swaraj Mazda truck	7	2	2	28
		Van	2	1.5	2	6
		Total				**218**

Status of Municipal Solid Waste Management
C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
116	Thanjavur M	Truck	11	1	2	22
		Tippers	2	2	2	8
		Tractor	1	2	2	4
		Total				**34**
117	Tiruchirapalli M.Corp.	Truck	31	n.a.	2	n.a.
		Tractor	4		2	
		Pick up van	11		4	
		Total				280
118	Tirunelveli M.Corp.	Truck	4	2	3	24
		Mini-Truck	14	1	3	42
		Tractor	4	1	3	12
		Tippers	2	1	3	6
		Container	2	0.5	3	3
		Total				**87**
119	Tirunvannamalai M	Tippers	3	3	2	15
		Tippers (small)	2	1	3	6
		Truck	1	1.5	2	3
		DCM truck	4	1	2	8
		Total				**32**
120	Tiruppur M	Truck	7	3	2	42
		Mini-Truck	7	2	3	42
		Tractor	4	1	3	12
		Tippers	2	1	2	4
		Total				**100**
121	Tuticorin M	Tiller	2	3	1	6
		Truck	3	1	2	6
		Tractor	4	2	1	8
		Mini van	5	1	1	5
		Total				**25**
122	Vellore M	Truck	8	2	2	
		Power tiller	4	1	1	
		Total				**35**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Uttar Pradesh					
123	Agra M.Corp.	Tippers	24	n.a.	7	n.a.
		Tractor	6		5	
		D.P.	3		3	
		Total				**430**
124	Aligarh M.Corp.	Tractor Trolley	16	1.8	3	84
		Truck	12	5	2	120
		Tippers	2	2	3	12
		Refuse Collector	2	10	3	60
		Total				**276**
125	Allahabad M.Corp.	Tippers	15	3	4	180
		Refuse Collector	4	8	2	64
		Tractor Trolley	3	1.5	2	9
		Total				**253**
126	Bareilly M.Corp.	Refuse Collector	3	15	1	45
		Dumper placer	3	1	5	15
		Tractor Trolley	21	2	4	168
		Tippers	6	4	4	96
		Total				**324**
127	Etawah MB	Tractor	5	n.a.	4	
		Total				**27**
128	Faizabad MB	Dumper	2	n.a.	5	n.a.
		Tractor Trolley	2		5	
		Total				**54**
129	Firozabad MB	Tractor	6	2	3	36
		Truck	4	4	6	96
		DCM Truck	1	4	3	12
		Total				**144**
130	Ghaziabad M.Corp.	Tippers	6	n.a.	6	n.a.
		Tractor Trolley	24		3	
		Carrier	1		5	
		Total				**300**

Status of Municipal Solid Waste Management
C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
131	Gorakhpur M.Corp.	Tractor Trolley	18	2	4	144
		Truck	6	3	3	54
		Refuse Collector	3	4	2	24
		Dumper	2	4	2	16
		Total				**238**
132	Haldwani-cum-Kathgodam MB	Truck	1	2	10	20
		Tractor Trolley	3	2	3	18
		Total				**38**
133	Hapur MB	Tractor	4	4	5	70
		Total				**70**
134	Hardwar MB	Tractor	7	2	4	56
		Gas mover	1	1	3	3
		Truck	5	3	6	90
		Carrier bin	22	1.5	1	33
		Total				**182**
135	Jhansi MB	Tractor Trolley	13	1.5	5	98
		Dumper	1	9	4	36
		Total				**134**
136	Mathura MB	Truck	2	5	5	50
		Dumper placer	3	3	6	54
		LCV	1	3	3	9
		Tractor	4	1.5	2	12
		Bullock Carts	25	0.5	2	25
		Total				**150**
137	Meerut M.Corp.	Tractor Trolley	14	2	5	140
		Tippers	8	5	5	200
		Truck	12	4	4	168
		Total				**508**
138	Mirzapur MB	Tractor Trolley	15	2	2	60
		Dumper	1	2	5	10
		Bullock Carts	2	0.4	3	2
		Total				**72**
139	Moradabad M.Corp.	Tractor	12	3	5	150
		Truck	2	5	7	70
		Swaraj Mazda	3	4	7	74
		Total				**294**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
140	Muzaffarnagar MB	Tippers	2	3	5	25
		Tractor Trolley	8	4	3	96
		Hand cart	125	0.05	2	13
		Total				**134**
141	Rae Bareli MB	Dumper	1	4	6	24
		Tractor Trolley	3	2	6	36
		Total				**60**
142	Rampur MB	Tractor	18	1	6	108
		Tippers	2	1	6	12
		Total				**120**
143	Saharanpur MB	Truck	8	4	2	64
		Tractor Trolley	10	4	2	80
		Mini-Truck	8	3	2	48
		Gas mover	1	4	2	8
		Total				**200**
144	Sitapur MB	Tractor Trolley	8	1	4	32
		Tippers	7	1	2	14
		Tempo	2	3	4	24
		Total				**70**
145	Unnao MB	Tractor	2	1	4	8
		Total				**8**
	West Bengal					
146	Asansol M.Corp.	Truck	23	2	n.a.	n.a.
		Total				**60**
147	Baharampur M	Truck	1	3	3	9
		Tractor	12	2	3	72
		Total				**81**
148	Balurghat M	Truck	1	3	5	15
		Tractor	2	3	3	18
		Total				**33**
149	Bankura M	Tractor	6	4	1	22
		Handcarts	20	0.3	1	5
		Total				**27**
150	Barasat M	Tractor	3	2	3	18
		Truck	1	3	3	9
		Total				**27**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
151	Burdwan M	Truck	6	n.a.	4	67
		Tractor Trolley	2	2	2	8
		Total				**75**
152	Halisahar M	Tractor	3	2	3	18
		Total				**18**
153	Krishna Nagar M	Truck	1	4	3	12
		Tractor Trolley	4	2	3	24
		Total				**36**
154	Midnapur M	Truck	3	3	5	45
		Tractor Trailer	2	2	2	8
		Total				**53**
155	North Barrackpur M	Tractor	5	2	3	30
		Truck	1	3	3	9
		Total				**39**
156	Santipur M	Truck	1	2	2	4
		Tractor	5	1.5	4	30
		Total				**34**
157	Siliguri M.Corp.	Tractor	4	n.a.	3	
		Truck	6		3	
		Total				**150**
	Small States					
	Assam					
158	Guwahati M.Corp.	Truck (large)	25	3	3	225
		Truck (small)	3	1	5	15
		Total				**240**
159	Jorhat MB	Truck	2	1.5	3	9
		Tractor Trolley	3	n.a.	3	5
		Total				**14**
	Manipur					
160	Imphal MCl	Truck	2	1	2	4
		Dumper	4	1.5	4	24
		Tractor Trolley	4	1	4	16
		Total				**44**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Meghalaya					
161	Shillong MB	Tipper	4	n.a.	1	31
		Truck	6		1	47
		Total				**78**
	Tripura					
162	Agartala MCl	Truck	9	3	2	50
		Tractor Trolley	1	2	2	4
		Tipper	2	1.8	2	7
		Total				**61**
	Union Territories					
163	Chandigarh M.Corp.	Dumper	16	1	7	112
		Compactors	5	3	3	45
		Tractor Trolley	20	1.5	4	120
		Truck	1	1	3	3
		Total				**280**
164	Pondicherry M	Tipper	7	4	2	56
		Truck	6	3	2	36
		Power tiller	2	0.5	4	4
		Tractor	3	2	3	18
		Total				**114**

Note : Data for average waste transported was furnished by the respective urban local bodies. The number of vehicles, multiplied by the average capacity and number of trips may not addup to the waste transported.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Class II					
	Andhra Pradesh					
1	Anakapalle M	Tractor	4	2	3	24
		Tractor (hired)	2	2	3	12
		Tipper	1	3	1	3
		Tiller	6	0.9	3	16
		Total				**55**
2	Dharmavaram M	Tractor	2	1.5	3	9
		Total				**9**
3	Gudur MCl	Tractor	3	2	3	18
		Total				**18**
4	Kapra M	Tractor	6	1.5	5	45
		Total				**45**
5	Kavali MCl	Tractor	3	2	4	24
		Total				**24**
6	Madanapalle M	Tractor	4	3	1	12
		Tractor (hired)	2	2	2	8
		Total				**20**
7	Narasaraopet M	Tractor	3	3	3	23
		Bullock Carts	9	0.3	5	11
		Tipper	4	2	1	8
		Total				**42**
8	Rajendra Nagar MCl	Tractor	1	1.5	3	5
		Truck	1	2	2	4
		Total				**9**
9	Sangareddy MCl	Tractor	1	1.5	3	5
		Tractor (hired)	3	1.5	2	9
		Total				**14**
10	Srikakulam MCl	Tractor	3	2	3	18
		Tractor (hired)	2	2	4	16
		Total				**34**
11	Srikalahasti M	Tractor trailor	2	2	6	24
		Total				**24**
12	Suryapet MCl	Tractor	3	2	5	30
		Total				**30**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Bihar					
13	Buxar M	Tractor	2	3	2	12
		Total				**12**
14	Deoghar M	Tractor	1	1.5	6	9
		Handcarts	n.a.	n.a.	n.a.	1
		Total				**10**
15	Hajipur M	Tractor	3	n.a.	2	24
		Total				**24**
16	Hazaribagh M	Tractor	3	1	3	9
		Truck	3	3	3	27
		Total				**36**
17	Jehanabad M	Tractor	1	3	4	10
		Total				**10**
18	Madhubani M	Tractor	4	1	4	16
		Total				**16**
19	Mokama M	Tractor (hired)	1	4	1	4
		Total				**4**
	Gujarat					
20	Amreli M	Tractor	4	1	8	30
		Total				**30**
21	Ankleswar M	Tractor Trolley	3	1	2	6
		Total				**6**
22	Dabhoi M	Truck	1	3	6	18
		Total				**18**
23	Dohad M	Truck	1	1	1	1
		Tractor	3	0.5	2	3
		Total				**4**
24	Gondal M	Two wheeler	25	n.a.	8	n.a.
		Tractor	7		1	
		Total				**0**
25	Jetpur M	Tractor	3	1.5	8	36
		Handcarts	24	n.a.	7	4
		Total				**40**
26	Mahesana M	Tractor	4	1	2	8
		Total				**8**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
27	Palanpur M	Tractor	3	4	3	32
		Auto	2	n.a.	n.a.	10
		Total				**42**
	Haryana					
28	Jind MCl	Tractor Trolley	3	1.5	4	18
		Total				**18**
29	Kaithal MCl	Tractor Trolley	4	1	3	12
		Total				**12**
30	Rewari MCl	Tractor Trolley	3	1.3	4	16
						16
31	Thanesar MCl	Tractor Trolley	4	1	3	12
		Refuse Collector	1	10	1	10
		Thela	3	0.3	3	2
		Total				**24**
	Karnataka					
32	Bagalkot CMC	Tractor	3	1.5	2	9
		Truck	1	2	2	4
		Total				**13**
33	Chikmagalur CMC	Truck	2	3	2	12
		Tractor	2	1.5	2	6
		Total				**18**
34	Gokak CMC	Tractor	2	1.5	1	3
		Tempo	2	1.5	2	6
		Total				**9**
35	Hospet CMC	Tractor	3	1.5	5	23
		Tippers	1	3	4	10
		Total				**33**
36	Kolar CMC	Tractor	4	2	1	8
		Tippers	1	3	3	8
		Total				**16**
37	Rabkavi-Banhatti CMC	Municipality sells waste	not applicable			
		Total				
38	Ramanagaram CMC	Truck	2	1.5	3	9
		Tractor	1	1	2	2
		Total				**11**

Status of Municipal Solid Waste Management
C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Kerala					
39	Changanessary MC	Truck	1	2	2	4
		Tempo	2	1	2	4
		Tiller	1	0.5	2	1
		Tractor	1	1.5	2	3
		Total				**12**
40	Payyanur M	Truck	1	2	2	4
		Total				**4**
41	Taliparamba M	Truck	1	3	1	3
		Total				**3**
42	Thrissur MC	Truck	11	2	1	22
		Tractor	3	2	2	12
		Tipper	1	0.5	2	1
		Total				**35**
	Madhya Pradesh					
43	Hoshangabad M	Tractor trolley	2	1.5	5	15
		Total				**15**
44	Itarsi M	Tractor trolley	5	1.3	2	13
		Truck	1	3	1	3
		Total				**15**
45	Khargone M	Tractor trolley	3	1	2	6
		Total				**6**
46	Mandsaur M	Truck	1	4	2	8
		Tractor trolley	3	3	2	18
		Total				**26**
47	Nagda M	Dumper	1	3	3	9
		Tractor trolley	1	1	1	1
		Total				**10**
48	Neemuch M	Tractor trolley	4	n.a.	2	n.a.
		Truck	1		2	
		Auto rickshaw	1		3	
		Total				**8**
49	Sehore M	Tractor trolley	4	2	4	30
		Total				**30**
50	Shahdol M	Tractor trolley	4	1.2	3	9
		Total				**9**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
51	Vidisha M	Tractor trolley	5	0.5	4	10
		Total				**10**
	Maharashtra					
52	Amalner MCl	Tractor	3	n.a.	3	n.a.
		Truck	1		2	
		Total				**6**
53	Ballarpur MCl	S.Model Truck	1	2	3	6
		Truck	1	2	3	6
		Tractor	3	2	1	6
		Total				**18**
54	Bhandara M	Truck	1	3	2	6
		Tractor Trolley	3	2	1	6
		Total				**12**
55	Kamptee MCl	Handcarts	30	0.03	6	5
		Refuse trolley	4	0.5	8	16
		Tippers	3	1.1	7	23
		Private trolley	2	0.5	6	6
		Total				**45**
56	Manmad MCl	Truck	1	1	1	1
		Tractor	2	3	1	5
		Total				**6**
57	Ratnagiri MCl	Truck	3	3	2	15
		Tippers	1	4	2	8
		Total				**23**
58	Satara MCl	Truck (large)	2	2	3	12
		Truck (small)	1	1.5	3	5
		Total				**17**
59	Virar MCl	Tractor	4	2	2	16
		Dumper	2	5	2	20
		Tipper	2	2	2	8
		Truck	1	3	2	6
		Total				**50**
	Punjab					
60	Ferozepur MCl	Tractor Trolley	5	2	4	40
		Total				**40**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
61	Kapurthala M	Tractor Trolley	4	1	3	n.a.
		Dumper placer	40	n.a.	n.a.	
		Total				**10**
62	Mansa MCl	Tractor Trolley	3	1.5	6	27
		Total				**27**
63	Phagwara MCl	Tractor Trolley	4	1.3	2	10
		Truck	1	2	2	4
		Total				**14**
64	Sangrur MCl	Tractor Trolley	3	3	2	15
		Total				**15**
	Rajasthan					
65	Banswara M	Tractor Trolley	2	n.a.	8	n.a.
		Dumper	2		12	
		Loader	1		n.a.	
		Total				**25**
66	Barmer M	Tractor	4	3	1	12
		Truck	2	1	3	6
		Total				**18**
67	Bundi M	Tractor Trolley	3	2	4	24
		Total				**24**
68	Churu M	Tractor Trolley	4	3	2	24
		Donkey cart	15	0.2	2	6
		Total				**30**
69	Hanumangarh M	Tractor	7	1.5	4	42
		Total				**42**
70	Sawai Madhopur M	Tractor Trolley	4	1	1	4
		Total				**4**
	Tamil Nadu					
71	Ambur M	Truck	1	2	3	6
		Mini-Truck	1	1	4	4
		Tractor	2	1	3	6
		Total				**16**
72	Arakkonam M	Bullock Cart	6	0.3	2	3
		Truck	4	2	1	8
		Total				**11**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
73	Attur M	Truck	1	2	2	4
		Mini-Truck	3	1	2	6
		Total				**10**
74	Cumbum M	Mini-Truck	2	0.6	2	2
		Tractor	1	0.5	2	0.9
		Total				**3**
75	Dharmapuri M	Truck	2	1.8	2	7
		Bullock Carts	16	0.3	1	4
		Total				**11**
76	Gudiyatham M	Truck	2	3	3	17
		Total				**17**
77	Nagapattinam M	Truck	4	1.5	4	24
		Total				**24**
78	Pudukkottai M	Truck	2	2	2	8
		Mini-Truck	3	1	2	6
		Tractor	2	1.5	2	6
		Total				**20**
79	Sivakasi M	Truck	1	1	1	1
		Mini-Truck	3	1	1	3
		Tractor	3	0.5	1	2
		Total				**6**
80	Srivilliputtur M	Mini-Truck	4	3	2	20
		Total				**20**
81	Tindivanam M	Truck	1	2	2	4
		Mini-Truck	2	1	2	4
		Tractor	2	1	2	4
		Total				**12**
82	Udhagamandalam M	Truck	3	1.5	1	5
		Mini-Truck	3	1	1	3
		Total				**8**
	Uttar Pradesh					
83	Auraiya MB	Tractor Trolley	2	1.5	7	21
		Total				**21**
84	Balrampur MB	Tractor	2	2	2	8
		Dumper	1	4	3	12
		Total				**20**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
85	Basti MB	Tractor	5	4	2	35
		Total				**35**
86	Bhadohi MB	Tractor Trolley	2	2	8	32
		Handcarts	20	0.08	5	8
		Total				**40**
87	Chandpur MB	Tractor Trolley	2	0.5	3	3
		Bullock Carts	8	0.1	2	2
		Handcarts	6	0.02	2	0.2
		Total				**5**
88	Etah MB	Tractor Trolley	2	2	4	16
		Tippers	1	3	8	24
		Total				**40**
89	Ghazipur MB	Tractor Trolley	3	3	2	18
		Dumper	1	3	3	9
		Total				**27**
90	Gonda MB	Tractor Trolley	3	3	3	27
		Total				**27**
91	Lakhimpur MB	Tractor Trolley	2	n.a.	2	14
		Dumper	1	1.5	6	21
		Total				**35**
92	Lalitpur MB	Tractor	4	4	3	48
		Dumper	1	2	3	6
		Total				**54**
93	Mughalsarai MB	Tractor Trolley	3	4	3	36
		Power tiller	2	n.a.	2	1
		Handcarts	183	0.03	2	11
		Total				**48**
94	Nawabganj-Barabanki MB	Tractor	3	1	2	6
		Total				**6**
95	Orai MB	Tractor Trolley	3	1	5	15
		Handcarts	50	0.04	8	14
		Total				**29**
96	Roorkee MB	Tractor Trolley	3	3	3	27
		Total				**27**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	West Bengal					
97	Bishnupur M	Tractor Trailer	2	2	2	8
		Handcarts	30	0.2	1	5
		Total				**13**
98	Chakdaha M	Handcarts	8	0.1	4	3
		Tractor Trailer	1	2	2	4
		Total				**7**
99	Contai M	Tractor Trolley	6	0.8	1	5
		Truck	3	1.3	1	4
		Total				**9**
100	Cooch Behar M	Wheel barrow	20	0.01	2	0.3
		Three wheeler	20	0.05	2	2
		Tractor Trolley	3	1	2	6
		Truck	2	3	2	10
		Auto van	2	0.5	3	3
		Total				**21**
101	Darjeeling M	Mini-Truck	4	1.3	3	15
		Truck	n.a.	n.a.	n.a.	15
		Total				**30**
102	Jalpaiguri M	Truck	3	2	3	18
		Tractor	2	1	1	2
		Total				**20**
103	Jangipur M	Tractor & Trailer	2	3	3	18
		Total				**18**
104	Katwa M	Tractor Trailer	6	2	3	36
		Total				**36**
105	Raniganj M	Tractor Trailer	6	2	3	41
		Total				**41**

Status of Municipal Solid Waste Management

C-4:Transportation Vehicles and their Details

Sl.	City/Town	Type	Number	Approx. Capacity	Avg. no. of trips per day	Approx. waste transported daily
	1	2	3	4	5	6
	Small States					
	Himachal Pradesh					
106	Shimla M.Corp.	Dumper placer	5	n.a.	8	n.a.
		Tipper	3		3	
		Total				**35**
	Nagaland					
107	Kohima TC	Truck	2	2	4	16
		Tractor Trailor	2	1.1	3	6
		Total				**22**
	Union Territories					
108	Port Blair MCl	Tipper	7	2	3	42
		Tractor Trolley	1	1	2	2
		Total				**44**
	Others(Smaller than Class II towns)					
	Small States					
	Goa					
109	Panaji MCl	Compactor	6	n.a.	2	n.a.
		Dumper Truck	7		2	
		Truck	1		2	
		Total				**11**
	Sikkim					
110	Gangtok (Greater Gangtok) NTAC	Truck	7	5	1	35
		Total				**35**
	Union Territories					
111	Daman MCl	Truck	2	3	1	5
		Tempo	2	1	2	4
		Tractor	1	1.5	1	2
		Others	1	0.5	1	0.5
		Total				**11**
112	Silvassa CT	Dumper	1	2	1	2
		Hydraulic Dumper	1	2	1	2
		Total				**4**

Note : Data for average waste transported was furnished by the respective urban local bodies. The number of vehicles, multiplied by the average capacity and number of trips may not addup to the waste transported.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
	Metropolitan Cities									
1	Ahmedabad M.Corp.	500	39	-	-	773	61	-	-	1273
2	Bangalore M.Corp.	440	20	-	-	1760	80	-	-	2200
3	Bhopal M.Corp.	100	28	260	72	-	-	-	-	360
4	Calcutta M.Corp.	300	14	1800	86	-	-	-	-	2100
5	Chennai M.Corp.	-	-	-	-	2500	100	-	-	2500
6	Coimbatore M.Corp.	-	-	-	-	670	100	-	-	670
7	Delhi M.Corp.	150	3	5350	97	-	-	-	-	5500
8	Greater Mumbai M.Corp.	100	2	5900	98	-	-	-	-	6000
9	Hyderabad M.Corp.	40	2	-	-	1845	97	15	1	1900
10	Indore M.Corp.	-	-	-	-	600	100	-	-	600
11	Jaipur M.Corp.	-	-	1483	100	-	-	-	-	1483
12	Kanpur M.Corp.	-	-	-	-	1100	100	-	-	1100
13	Kochi M.Corp.	-	-	-	-	240	100	-	-	240
14	Lucknow M.Corp.	-	-	-	-	875	100	-	-	875
15	Ludhiana M.Corp.	-	-	-	-	875	100	-	-	875
16	Madurai M.Corp.	30	7	-	-	420	93	-	-	450
17	Nagpur M.Corp.	-	-	100	20	400	80	-	-	500
18	Pune M.Corp.	-	-	900	100	-	-	-	-	900
19	Surat M.Corp.	-	-	960	100	-	-	-	-	960
20	Vadodara M.Corp.	-	-	-	-	440	100	-	-	440
21	Varanasi M.Corp.	-	-	-	-	461	100	-	-	461
22	Visakhapatnam M.Corp.	-	-	600	100	-	-	-	-	600
	Total-Metropolitan Cities	**1660**	**5.2**	**17353**	**54.25**	**12959**	**40.5**	**15**	**0.05**	**31987**

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
	Class I									
	Andhra Pradesh									
1	Anantapur MCl	60	55	-	-	50	45	-	-	110
2	Chittoor M	35	50	12	17	23	33	-	-	70
3	Cuddapah MCl	-	-	-	-	84	100	-	-	84
4	Eluru M	6	4	-	-	140	96	-	-	146
5	Guntur MCl	250	100	-	-	-	-	-	-	250
6	Hindupur M	-	-	-	-	70	100	-	-	70
7	Kakinada M	-	-	-	-	145	100	-	-	145
8	Kurnool MCl	-	-	90	100	-	-	-	-	90
9	Machilipatnam M	45	90	-	-	5	10	-	-	50
10	Nandyal MCl	36	60	-	-	24	40	-	-	60
11	Nellore MCl	-	-	-	-	167	100	-	-	167
12	Nizamabad M	-	-	-	-	88	100	-	-	88
13	Ongole MCl	-	-	-	-	90	100	-	-	90
14	Qutubullapur M	-	-	-	-	70	100	-	-	70
15	Rajahmundry M.Corp.	-	-	-	-	193	100	-	-	193
16	Tenali M	64	80	-	-	16	20	-	-	80
17	Tirupati MCl	-	-	-	-	130	100	-	-	130
18	Vijaywada M.Corp.	-	-	300	65	-	-	165	35	465
19	Warangal M.Corp.	-	-	-	-	230	100	-	-	230
	Bihar									
20	Bihar Sharif M	-	-	-	-	50	100	-	-	50
21	Chhapra M	-	-	-	-	66	100	-	-	66
22	Gaya M.Corp.	-	-	-	-	80	100	-	-	80
23	Katihar M	-	-	-	-	45	100	-	-	45
24	Munger M	-	-	-	-	50	100	-	-	50
25	Ranchi M.Corp.	-	-	-	-	34	100	-	-	34
	Gujarat									
26	Anand M	-	-	-	-	10	100	-	-	10
27	Bharuch M	-	-	-	-	85	100	-	-	85
28	Bhavnagar M.Corp.	-	-	-	-	115	100	-	-	115

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
29	Bhuj M	-	-	-	-	40	100	-	-	40
30	Jamnagar M.Corp.	-	-	-	-	300	100	-	-	300
31	Junagadh M	-	-	-	-	75	100	-	-	75
32	Nadiad M	-	-	-	-	60	100	-	-	60
33	Navsari M	-	-	-	-	31	100	-	-	31
34	Porbandar M	-	-	-	-	22	100	-	-	22
35	Rajkot M.Corp.	-	-	-	-	425	100	-	-	425
36	Surendranagar M	-	-	-	-	31	100	-	-	31
	Haryana									
37	Ambala MCl	-	-	-	-	30	100	-	-	30
38	Faridabad M.Corp.	-	-	-	-	480	100	-	-	480
39	Gurgaon MCl	-	-	-	-	80	100	-	-	80
40	Hissar MCl	-	-	-	-	32	100	-	-	32
41	Karnal MCl	-	-	-	-	52	100	-	-	52
42	Rohtak MCl	-	-	-	-	28	100	-	-	28
	Jammu & Kashmir									
43	Jammu M.Corp.	-	-	-	-	300	100	-	-	300
44	Srinagar M.Corp.	-	-	-	-	200	100	-	-	200
	Karnataka									
45	Belgaum M.Corp.	-	-	100	100	-	-	-	-	100
46	Bellary CMC	-	-	-	-	50	100	-	-	50
47	Davangere MCl	78	100	-	-	-	-	-	-	78
48	Gadag-Betigeri CMC	10	17	-	-	50	83	-	-	60
49	Gulbarga M.Corp.	-	-	-	-	76	100	-	-	76
50	Hubli-Dharwad M.Corp.	-	-	-	-	220	100	-	-	220
51	Mandya M	-	-	-	-	25	100	-	-	25
52	Mangalore M.Corp.	-	-	-	-	70	100	-	-	70
53	Mysore M.Corp.	-	-	-	-	205	100	-	-	205
54	Shimoga CMC	-	-	-	-	72	100	-	-	72
55	Tumkur M	-	-	-	-	84	100	-	-	84

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
	Kerala									
56	Alappuzha MC	-	-	-	-	20	100	-	-	20
57	Kollam MC	-	-	-	-	58	100	-	-	58
58	Kozhikode M.Corp.	-	-	-	-	154	100	-	-	154
59	Thalaserry M	30	100	-	-	-	-	-	-	30
60	Thiruvananthapuram M.Corp.	-	-	-	-	250	100	-	-	250
	Madhya Pradesh									
61	Bhind M	-	-	-	-	24	100	-	-	24
62	Burhanpur M.Corp.	21	35	-	-	39	65	-	-	60
63	Dewas M.Corp.	-	-	20	50	20	50	-	-	40
64	Guna M	-	-	-	-	18	100	-	-	18
65	Gwalior M.Corp.	100	36	-	-	180	64	-	-	280
66	Jabalpur M.Corp.	-	-	-	-	298	100	-	-	298
67	Khandwa M	10	50	5	25	5	25	-	-	20
68	Morena M	-	-	-	-	44	100	-	-	44
69	Murwara-Katni M.Corp.	-	-	-	-	63	100	-	-	63
70	Ratlam M.Corp.	-	-	-	-	35	100	-	-	35
71	Rewa M.Corp.	-	-	-	-	40	100	-	-	40
72	Satna M.Corp.	-	-	-	-	50	100	-	-	50
73	Shivpuri M	-	-	-	-	18	100	-	-	18
	Maharashtra									
74	Amravati M.Corp.	-	-	-	-	100	100	-	-	100
75	Aurangabad M.Corp.	10	3	-	-	330	97	-	-	340
76	Bhusawal M.Cl.	-	-	-	-	30	100	-	-	30
77	Chandrapur MCl	-	-	70	64	40	36	-	-	110
78	Dhule MCl	-	-	-	-	30	100	-	-	30
79	Ichalkaranji MCl	150	100	-	-	-	-	-	-	150
80	Jalgaon MCl	-	-	220	100	-	-	-	-	220
81	Kolhapur M.Corp.	-	-	-	-	115	100	-	-	115
82	Nanded Waghala M.Corp.	-	-	-	-	90	100	-	-	90
83	Nashik M.Corp.	-	-	-	-	280	100	-	-	280

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
84	Parbhani MCl	-	-	-	-	72	100	-	-	72
85	Solapur M.Corp.	353	100	-	-	-	-	-	-	353
86	Wardha M	-	-	10	25	30	75	-	-	40
87	Yavatmal MCl	-	-	-	-	10	100	-	-	10
	Orissa									
88	Bhubaneswar M.Corp.	-	-	-	-	175	100	-	-	175
89	Cuttack M.Corp.	-	-	-	-	320	100	-	-	320
90	Puri M	-	-	-	-	53	100	-	-	53
91	Rourkela M	-	-	-	-	40	100	-	-	40
92	Sambalpur M	-	-	-	-	32	100	-	-	32
	Punjab									
93	Amritsar M.Corp.	-	-	200	39	310	61	-	-	510
94	Bathinda MCl	-	-	-	-	95	100	-	-	95
95	Hoshiarpur MCl	-	-	-	-	33	100	-	-	33
96	Jalandhar M. Corp.	-	-	-	-	236	100	-	-	236
97	Moga MCl	-	-	36	100	-	-	-	-	36
98	Pathankot MCl	-	-	23	100	-	-	-	-	23
99	Patiala M.Corp.	-	-	80	100	-	-	-	-	80
	Rajasthan									
100	Ajmer MCl	-	-	-	-	250	100	-	-	250
101	Alwar M	-	-	-	-	100	100	-	-	100
102	Beawar M	-	-	-	-	42	100	-	-	42
103	Bhilwara M	-	-	-	-	58	100	-	-	58
104	Bikaner M	-	-	-	-	180	100	-	-	180
105	Jodhpur M.Corp.	-	-	-	-	308	100	-	-	308
106	Kota M.Corp.	-	-	20	17	100	83	-	-	120
107	Sriganganagar M	-	-	-	-	24	100	-	-	24
	Tamil Nadu									
108	Cuddalore M	60	100	-	-	-	-	-	-	60
109	Dindigul M	17	100	-	-	-	-	-	-	17
110	Erode M	-	-	-	-	85	100	-	-	85

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
111	Kanchipuram M	19	100	-	-	-	-	-	-	19
112	Kumbakonam M	-	-	-	-	40	100	-	-	40
113	Nagercoil M	30	100	-	-	-	-	-	-	30
114	Rajapalaiyam M	-	-	-	-	43	100	-	-	43
115	Salem M.Corp.	21	10	156	73	-	-	36	17	214
116	Thanjavur M	35	100	-	-	-	-	-	-	35
117	Tiruchirapalli M.Corp.	280	100	-	-	-	-	-	-	280
118	Tirunelveli M.Corp.	-	-	-	-	87	100	-	-	87
119	Tirunvannamalai M	32	100	-	-	-	-	-	-	32
120	Tiruppur M	-	-	-	-	100	100	-	-	100
121	Tuticorin M	-	-	-	-	25	100	-	-	25
122	Vellore M	24	69	10	29	-	-	1	3	35
	Uttar Pradesh									
123	Agra M.Corp.	30	7	400	93	-	-	-	-	430
124	Aligarh M.Corp.	-	-	-	-	275	100	-	-	275
125	Allahabad M.Corp.	-	-	-	-	250	100	-	-	250
126	Bareilly M.Corp.	-	-	-	-	320	100	-	-	320
127	Etawah MB	-	-	-	-	27	100	-	-	27
128	Faizabad MB	-	-	-	-	54	100	-	-	54
129	Firozabad MB	-	-	-	-	144	100	-	-	144
130	Ghaziabad M.Corp.	-	-	-	-	300	100	-	-	300
131	Gorakhpur M.Corp.	-	-	-	-	240	100	-	-	240
132	Haldwani-cum-Kathgodam MB	-	-	-	-	80	100	-	-	80
133	Hapur MB	20	29	-	-	50	71	-	-	70
134	Hardwar MB	-	-	-	-	182	100	-	-	182
135	Jhansi MB	-	-	89	66	35	26	11	8	135
136	Mathura MB	40	27	-	-	110	73	-	-	150
137	Meerut M.Corp.	-	-	-	-	500	100	-	-	500
138	Mirzapur MB	-	-	-	-	86	100	-	-	86
139	Moradabad M.Corp.	-	-	-	-	300	100	-	-	300
140	Muzaffarnagar MB	-	-	-	-	130	100	-	-	130
141	Rae Bareli MB	-	-	-	-	66	100	-	-	66

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
142	Rampur MB	120	100	-	-	-	-	-	-	120
143	Saharanpur MB	-	-	-	-	200	100	-	-	200
144	Sitapur MB	-	-	-	-	70	100	-	-	70
145	Unnao MB	-	-	-	-	8	100	-	-	8
	West Bengal									
146	Asansol M.Corp.	-	-	-	-	60	100	-	-	60
147	Baharampur M	2	2	49	60	25	31	5	6	81
148	Balurghat M	33	100	-	-	-	-	-	-	33
149	Bankura M	-	-	-	-	26	100	-	-	26
150	Barasat M	-	-	-	-	24	100	-	-	24
151	Burdwan M	-	-	75	100	-	-	-	-	75
152	Halisahar M	-	-	-	-	17	100	-	-	17
153	Krishna Nagar M	-	-	-	-	38	100	-	-	38
154	Midnapur M	49	91	5	9	-	-	-	-	53
155	North Barrackpur M	-	-	10	25	30	75	-	-	40
156	Santipur M	-	-	-	-	33	100	-	-	33
157	Siliguri M.Corp.	-	-	-	-	150	100	-	-	150
	Small States									
	Assam									
158	Guwahati M.Corp.	-	-	-	-	240	100	-	-	240
159	Jorhat MB	-	-	14	100	-	-	-	-	14
	Manipur									
160	Imphal MCl	-	-	-	-	38	100	-	-	38
	Meghalaya									
161	Shillong MB	-	-	-	-	78	100	-	-	78
	Tripura									
162	Agartala MCl	-	-	-	-	60	100	-	-	60
	Union Territories									
163	Chandigarh M.Corp.	-	-	280	100	-	-	-	-	280
164	Pondicherry M	120	100	-	-	-	-	-	-	120
	Total-Class I Cities	**2189**	**11**	**2274**	**12**	**14522**	**76**	**218**	**1**	**19204**

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
	Class II									
	Andhra Pradesh									
1	Anakapalle M	50	91	-	-	5	9	-	-	55
2	Dharmavaram M	9	100	-	-	-	-	-	-	9
3	Gudur MCl	-	-	18	100	-	-	-	-	18
4	Kapra M	-	-	-	-	48	100	-	-	48
5	Kavali MCl	-	-	24	100	-	-	-	-	24
6	Madanapalle M	20	100	-	-	-	-	-	-	20
7	Narasaraopet M	-	-	-	-	42	100	-	-	42
8	Rajendra Nagar MCl	-	-	12	100	-	-	-	-	12
9	Sangareddy MCl	-	-	18	100	-	-	-	-	18
10	Srikakulam MCl	-	-	-	-	25	100	-	-	25
11	Srikalahasti M	-	-	-	-	30	100	-	-	30
12	Suryapet MCl	-	-	30	75	10	25	-	-	40
	Bihar									
13	Buxar M	-	-	-	-	12	100	-	-	12
14	Deoghar M	-	-	-	-	10	100	-	-	10
15	Hajipur M	-	-	-	-	24	100	-	-	24
16	Hazaribagh M	-	-	-	-	36	100	-	-	36
17	Jehanabad M	-	-	-	-	10	100	-	-	10
18	Madhubani M	-	-	-	-	15	100	-	-	15
19	Mokama M	-	-	-	-	4	100	-	-	4
	Gujarat									
20	Amreli M	30	100	-	-	-	-	-	-	30
21	Ankleswar M	-	-	-	-	6	100	-	-	6
22	Dabhoi M	-	-	-	-	18	100	-	-	18
23	Dohad M	-	-	-	-	4	100	-	-	4
24	Gondal M	-	-	-	-	10	100	-	-	10
25	Jetpur M	-	-	-	-	40	100	-	-	40
26	Mahesana M	-	-	-	-	8	100	-	-	8
27	Palanpur M	-	-	-	-	40	100	-	-	40
	Haryana									
28	Jind MCl	-	-	-	-	18	100	-	-	18
29	Kaithal MCl	-	-	-	-	12	100	-	-	12
30	Rewari MCl	-	-	-	-	16	100	-	-	16
31	Thanesar MCl	-	-	-	-	24	100	-	-	24

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
	Karnataka									
32	Bagalkot CMC	-	-	-	-	13	100	-	-	13
33	Chikmagalur CMC	-	-	-	-	18	100	-	-	18
34	Gokak CMC	7	100	-	-	-	-	-	-	7
35	Hospet CMC	-	-	-	-	31	100	-	-	31
36	Kolar CMC	-	-	-	-	15	100	-	-	15
37	Rabkavi-Banhatti CMC	-	-	-	-	12	100	-	-	12
38	Ramanagaram CMC	-	-	-	-	10	100	-	-	10
	Kerala									
39	Changanessary MC	-	-	-	-	12	100	-	-	12
40	Payyanur M	-	-	-	-	4	100	-	-	4
41	Taliparamba M	3	100	-	-	-	-	-	-	3
42	Thrissur MC	-	-	-	-	35	100	-	-	35
	Madhya Pradesh									
43	Hoshangabad M	-	-	-	-	15	100	-	-	15
44	Itarsi M	-	-	-	-	15	100	-	-	15
45	Khargone M	6	100	-	-	-	-	-	-	6
46	Mandsaur M	-	-	-	-	26	100	-	-	26
47	Nagda M	-	-	-	-	10	100	-	-	10
48	Neemuch M	-	-	-	-	8	100	-	-	8
49	Sehore M	-	-	-	-	30	100	-	-	30
50	Shahdol M	-	-	-	-	9	100	-	-	9
51	Vidisha M	-	-	10	100	-	-	-	-	10
	Maharashtra									
52	Amalner MCl	5	83	-	-	1	17	-	-	6
53	Ballarpur MCl	-	-	-	-	18	100	-	-	18
54	Bhandara M	-	-	-	-	12	100	-	-	12
55	Kamptee MCl	-	-	40	100	-	-	-	-	40
56	Manmad MCl	4	80	-	-	1	20	-	-	5
57	Ratnagiri MCl	-	-	-	-	22	100	-	-	22
58	Satara MCl	-	-	-	-	17	100	-	-	17
59	Virar MCl	-	-	-	-	50	100	-	-	50
	Punjab									
60	Ferozepur MCl	-	-	16	40	24	60	-	-	40
61	Kapurthala M	-	-	5	50	5	50	-	-	10

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
62	Mansa MCl	-	-	-	-	27	100	-	-	27
63	Phagwara MCl	-	-	-	-	14	100	-	-	14
64	Sangrur MCl	-	-	-	-	15	100	-	-	15
	Rajasthan									
65	Banswara M	-	-	-	-	25	100	-	-	25
66	Barmer M	-	-	-	-	18	100	-	-	18
67	Bundi M	-	-	-	-	24	100	-	-	24
68	Churu M	-	-	-	-	30	100	-	-	30
69	Hanumangarh M	-	-	-	-	43	100	-	-	43
70	Sawai Madhopur M	-	-	-	-	4	100	-	-	4
	Tamil Nadu									
71	Ambur M	13	100	-	-	-	-	-	-	13
72	Arakkonam M	-	-	-	-	11	100	-	-	11
73	Attur M	-	-	-	-	10	100	-	-	10
74	Cumbum M	4	100	-	-	-	-	-	-	4
75	Dharmapuri M	-	-	-	-	11	100	-	-	11
76	Gudiyatham M	-	-	-	-	16	100	-	-	16
77	Nagapattinam M	-	-	-	-	25	100	-	-	25
78	Pudukkottai M	20	100	-	-	-	-	-	-	20
79	Sivakasi M	-	-	-	-	5	100	-	-	5
80	Srivilliputtur M	-	-	-	-	20	100	-	-	20
81	Tindivanam M	-	-	-	-	12	100	-	-	12
82	Udhagamandalam M	7	100	-	-	-	-	-	-	7
	Uttar Pradesh									
83	Auraiya MB	-	-	-	-	21	100	-	-	21
84	Balrampur MB	-	-	-	-	20	100	-	-	20
85	Basti MB	-	-	-	-	35	100	-	-	35
86	Bhadohi MB	-	-	-	-	40	100	-	-	40
87	Chandpur MB	-	-	-	-	5	100	-	-	5
88	Etah MB	-	-	-	-	40	100	-	-	40
89	Ghazipur MB	-	-	-	-	27	100	-	-	27
90	Gonda MB	-	-	-	-	25	100	-	-	25
91	Lakhimpur MB	-	-	-	-	35	100	-	-	35
92	Lalitpur MB	25	45	-	-	30	55	-	-	55

Status of Municipal Solid Waste Management

C-5: Disposal of Solid Waste, 1999

Sl. No.	City/Town	Quantity of solid waste treated/ disposed by								
		Composting		Land fill		Crude/ open dumping		Other methods		Total (MT/day)
		MT/day	%	MT/day	%	MT/day	%	MT/day	%	
	1	2	3	4	5	6	7	8	9	10
93	Mughalsarai MB	-	-	-	-	48	100	-	-	48
94	Nawabganj-Barabanki MB	-	-	-	-	6	100	-	-	6
95	Orai MB	-	-	-	-	29	100	-	-	29
96	Roorkee MB	12	44	-	-	15	56	-	-	27
	West Bengal									
97	Bishnupur M	-	-	-	-	13	100	-	-	13
98	Chakdaha M	-	-	-	-	7	100	-	-	7
99	Contai M	-	-	-	-	9	100	-	-	9
100	Cooch Behar M	-	-	-	-	21	100	-	-	21
101	Darjeeling M	-	-	-	-	30	100	-	-	30
102	Jalpaiguri M	-	-	-	-	21	100	-	-	21
103	Jangipur M	-	-	18	100	-	-	-	-	18
104	Katwa M	-	-	-	-	36	100	-	-	36
105	Raniganj M	-	-	-	-	-	-	41	100	41
	Small States									
	Himachal Pradesh									
106	Shimla M.Corp.	-	-	-	-	35	100	-	-	35
	Nagaland									
107	Kohima TC	-	-	-	-	23	100	-	-	23
	Union Territories									
108	Port Blair MCl	-	-	-	-	44	100	-	-	44
	Others(Smaller than Class II towns)									
	Small States									
	Goa									
109	Panaji MCl	-	-	11	100	-	-	-	-	11
	Sikkim									
110	Gangtok (Greater Gangtok) NTAC	-	-	-	-	35	100	-	-	35
	Union Territories									
111	Daman MCl	-	-	-	-	11	100	-	-	11
112	Silvassa CT	-	-	-	-	4	100	-	-	4
	Total-Class II Towns	**216**	**9**	**202**	**9**	**1855**	**80**	**41**	**2**	**2314**
	Grand Total	**4065**	**7.6**	**19829**	**37.1**	**29336**	**54.8**	**274**	**0.5**	**53505**

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-6: Composting Details, 1999

Sl. No.	City/Town	Quantity composted (MT)	Method of Composting
	1	2	3
	Metropolitan Cities		
1	Ahmedabad M.Corp.	500	Mechanical composting
2	Bangalore M.Corp.	500	Pit composting
3	Bhopal M.Corp.	100	Mechanical composting
4	Calcutta M.Corp.	300	
5	Delhi M.Corp.	650	Mechanical composting
6	Greater Mumbai M.Corp.	50	Wind rows
7	Hyderabad M.Corp.	40	Vermi-composting
8	Madurai M.Corp.	30	Pit composting
	Total-Metropolitan Cities	**2170**	

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-6: Composting Details, 1999

Sl. No.	City/Town	Quantity composted (MT)	Method of Composting
	1	2	3
	Class I		
	Andhra Pradesh		
1	Anantapur MCl	60	Pit composting
2	Chittoor M	35	Pit composting
3	Cuddapah MCl	-	Pit composting
4	Eluru M	6	Pit composting
5	Guntur MCl	250	Vermi-composting
6	Hindupur M	45	Pit composting
7	Kakinada M	36	Pit composting
8	Tenali M	64	n.a.
	Karnataka		
9	Davangere MCl	78	Pit composting
10	Gadag-Betigeri CMC	10	Pit composting
	Kerala		
11	Thalaserry M	30	Pit Composting
	Madhya Pradesh		
12	Burhanpur M.Corp.	21	Pit composting
13	Gwalior M.Corp.	100	Vermi-composting
14	Khandwa M	10	Pit composting
	Maharashtra		
15	Aurangabad M.Corp.	10	Excel technology
16	Ichalkaranji MCl	150	Pit composting
17	Solapur M.Corp.	353	Bangalore system
	Tamil Nadu		
18	Cuddalore M	60	Pit composting
19	Dindigul M	17	Pit composting

Status of Municipal Solid Waste Management

C-6: Composting Details, 1999

Sl. No.	City/Town	Quantity composted (MT)	Method of Composting
	1	2	3
20	Kanchipuram M	19	Pit composting
21	Nagercoil M	30	Pit composting
22	Salem M.Corp.	21	Pit composting
23	Thanjavur M	35	Pit composting
24	Tiruchirapalli M.Corp.	280	Pit composting
25	Tirunvannamalai M	32	Heap composting
26	Vellore M	24	Pit composting
	Uttar Pradesh		
27	Agra M.Corp.	30	Wind rows
28	Hapur MB	20	Pit composting
29	Mathura MB	40	Tranching
30	Rampur MB	120	Pit composting
	West Bengal		
31	Balurghat M	33	Pit composting
32	Baharampur M	2	Pit composting
33	Midnapur M	49	Pit composting
	Small States		
	Tripura		
34	Agartala MCl	31	Mechanical composting
	Union Territories		
35	Pondicherry M	120	Pit composting
	Total-Class I Cities	**2220**	

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-6: Composting Details, 1999

Sl. No.	City/Town	Quantity composted (MT)	Method of Composting
	1	2	3
	Class II		
	Andhra Pradesh		
1	Anakapalle M	50	Pit composting
2	Dharmavaram M	9	Pit composting
3	Madanapalle M	20	Wind rows
	Gujarat		
4	Amreli M	30	n.a.
	Karnataka		
5	Gokak CMC	7	Pit composting
	Kerala		
6	Taliparamba M	3	Pit Composting
	Madhya Pradesh		
7	Khargone M	6	Pit composting
	Maharashtra		
8	Amalner MCl	5	Pit composting
9	Manmad MCl	4	Pit composting
	Tamil Nadu		
10	Cumbum M	4	Heap composting
11	Pudukkottai M	20	Pit composting
12	Udhagamandalam M	7	Pit composting
	Uttar Pradesh		
13	Lalitpur MB	25	Pit & Vermi-composting
14	Roorkee MB	12	Pit composting
	Total-Class II Towns	**203**	
	Grand Total	**4593**	

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-7: Landfill Details, 1999

Sl. No.	City/Town	Existing Landfill site(s)			Future Landfill site(s)		
		No.	Area (ha)	Future life (yrs)	No.	Area (ha)	Expected life (yrs)
	1	2	3	4	5	6	7
	Metropolitan Cities						
1	Bangalore M.Corp.	n.a	n.a	n.a	2	8	20
2	Bhopal M.Corp.	2	6	n.a	1	11	n.a
3	Calcutta M.Corp.	5	8	n.a	n.a	n.a	n.a
4	Chennai M.Corp.	n.a	n.a	n.a	1	55	10
5	Delhi M.Corp.	4	60	3	1	10	10
6	Greater Mumbai M.Corp.	4	173	2	n.a	n.a	10
7	Indore M.Corp.	1	59	n.a	1	30	n.a
8	Jaipur M.Corp.	1	30	7	n.a	n.a	n.a
9	Kochi M.Corp.	n.a	n.a	n.a	1	18	n.a
10	Nagpur M.Corp.	1	16	n.a	n.a	n.a	n.a
11	Pune M.Corp.	2	29	10	n.a	n.a	n.a
12	Surat M.Corp.	2	7	1	1	200	50
13	Vadodara M.Corp.	n.a	n.a	n.a	1	2	50
14	Visakhapatnam M.Corp.	2	42	n.a	n.a	n.a	n.a

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-7: Landfill Details, 1999

Sl. No.	City/Town	Existing Landfill site(s)			Future Landfill site(s)		
		No.	Area (ha)	Future life (yrs)	No.	Area (ha)	Expected life (yrs)
	1	2	3	4	5	6	7
	Class I						
	Andhra Pradesh						
1	Chittoor M	1	2	2	-	-	-
2	Cuddapah MCl	-	-	-	1	9	25
3	Hindupur M	-	-	-	1	1	n.a.
4	Kurnool MCl	1	11	20	-	-	-
5	Nizamabad M	-	-	-	1	5	n.a.
6	Ongole MCl	-	-	-	1	16	n.a.
7	Vijaywada M.Corp.	3	10	n.a.	-	-	-
	Gujarat						
8	Rajkot M.Corp.	-	-	-	1	25	25
	Jammu & Kashmir						
9	Srinagar M.Corp.	1	n.a.	5	-	-	-
	Karnataka						
10	Belgaum M.Corp.	1	4	n.a.	1	43	n.a.
11	Mysore M.Corp.	-	-	-	1	3	n.a.
	Kerala						
12	Thalaserry M	-	-	-	1	5	20
13	Thiruvananthapuram M.Corp.	-	-	-	1	5	n.a.
	Madhya Pradesh						
14	Dewas M.Corp.	1	4	1	1	15	n.a.
15	Khandwa M	1	7	2	-	-	-
16	Rewa M.Corp.	-	-	-	1	6	n.a.
17	Satna M.Corp.	-	-	-	1	5	n.a.
18	Shivpuri M	-	-	-	1	9	n.a.
	Maharashtra						
19	Chandrapur MCl	1	11	4	-	-	-
20	Jalgaon MCl	1	n.a.	n.a.	-	-	-
21	Nanded Waghala M.Corp.	-	-	-	2	22	50
22	Solapur M.Corp.	-	-	-	1	2	15
23	Wardha M	1	12	10	-	-	-
	Punjab						
24	Moga MCl	1	6	5	-	-	-
25	Pathankot MCl	1	n.a.	n.a.	-	-	-
26	Patiala M.Corp.	4	5	4-6	-	-	-

Status of Municipal Solid Waste Management

C-7: Landfill Details, 1999

Sl. No.	City/Town	Existing Landfill site(s)			Future Landfill site(s)		
		No.	Area (ha)	Future life (yrs)	No.	Area (ha)	Expected life (yrs)
	1	2	3	4	5	6	7
	Rajasthan						
27	Ajmer MCl	-	-	-	1	100	50
28	Bhilwara M	-	-	-	1	45	3
29	Bikaner M	-	-	-	1	12	n.a.
30	Kota M.Corp.	5	n.a.	1	-	-	-
31	Sriganganagar M	-	-	-	1	6	1
	Tamil Nadu						
32	Kanchipuram M	-	-	-	1	0	10
33	Salem M.Corp.	4	19	n.a.	-	-	-
34	Vellore M	1	5	n.a.	1	10	n.a.
	Uttar Pradesh						
35	Agra M.Corp.	1	n.a.	1	1	40	15
36	Jhansi MB	5	15	20	-	-	-
	West Bengal						
37	Baharampur M	4	73	5-6	-	-	-
38	Burdwan M	1	2	-	1	7	25
39	Midnapur M	1	2	15	2	5	20
40	North Barrackpur M	1	1	2	-	-	-
	Small States						
	Assam						
41	Guwahati M.Corp.	-	-	-	1	n.a.	5
42	Jorhat MB	1	3	6	-	-	-
	Manipur						
43	Imphal MCl	-	-	-	1	n.a.	n.a.
	Tripura						
44	Agartala MCl	-	-	-	1	3	13
	Union Territories						
45	Chandigarh M.Corp.	1	45	15	-	-	-
46	Pondicherry M	-	-	-	1	4	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-7: Landfill Details, 1999

Sl. No.	City/Town	Existing Landfill site(s)			Future Landfill site(s)		
		No.	Area (ha)	Future life (yrs)	No.	Area (ha)	Expected life (yrs)
	1	2	3	4	5	6	7
	Class II						
	Andhra Pradesh						
1	Gudur MCl	1	1	-	1	5	30
2	Kavali MCl	2	3	10	1	4	25
3	Rajendra Nagar MCl	3	3	6	1	4	25
4	Sangareddy MCl	1	2	25	-	-	-
5	Suryapet MCl	2	20	-	1	1	5
	Karnataka						
6	Kolar CMC	-	-	-	1	8	-
	Kerala						
7	Changanessary MC	-	-	-	1	1	-
8	Payyanur M	-	-	-	1	5	15
9	Taliparamba M	-	-	-	1	0	20
	Madhya Pradesh						
10	Mandsaur M	-	-	-	1	3	10
11	Vidisha M	1	5	5	-	-	-
	Maharashtra						
12	Kamptee MCl	4	1	2	2	5	10
	Punjab						
13	Ferozepur MCl	1	-	3	-	-	-
14	Kapurthala M	1	1	5	-	-	-
	Rajasthan						
15	Barmer M	-	-	-	1	5	-
	West Bengal						
16	Bishnupur M	-	-	-	1	100	25
17	Chakdaha M	-	-	-	1	0	20
18	Jangipur M	2	10	50	2	35	50
	Small States						
	Nagaland						
19	Kohima TC	-	-	-	2	8	25
	Others(Smaller than Class II towns)						
	Small States						
	Goa						
20	Panaji MCl	1	1	10	-	-	-

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
	Metropolitan Cities				
1	Ahmedabad M.Corp.	400	8,500	8,900	2.4
2	Bangalore M.Corp.	326	5,700	6,026	1.1
3	Bhopal M.Corp.	21	1,000	1,021	0.67
4	Calcutta M.Corp.	1,560	13,500	15,060	2.8
5	Chennai M.Corp.	300	10,130	10,430	2.3
6	Coimbatore M.Corp.	126	2,483	2,609	2.6
7	Delhi M.Corp.	1,647	42,317	43,964	5.6
8	Greater Mumbai M.Corp.	1,200	35,526	36,726	3.2
9	Hyderabad M.Corp.	460	9,500	9,960	2.3
10	Indore M.Corp.	135	2,700	2,835	2.3
11	Jaipur M.Corp.	419	7,016	7,435	3.5
12	Kanpur M.Corp.	232	4,626	4,858	2.2
13	Kochi M.Corp.	102	847	949	1.2
14	Lucknow M.Corp.	120	3,940	4,060	2.3
15	Ludhiana M.Corp.	102	2,100	2,202	2.6
16	Madurai M.Corp.	202	2,534	2,736	2.5
17	Nagpur M.Corp.	70	3,629	3,699	1.7
18	Pune M.Corp.	9	1,867	1,876	0.81
19	Surat M.Corp.	24	675	699	0.27
20	Vadodara M.Corp.	61	2,660	2,721	1.9
21	Varanasi M.Corp.	120	2,665	2,785	2.9
22	Visakhapatnam M.Corp.	188	1,587	1,775	1.2
	Total-Metropolitan Cities	**7,824**	**165,502**	**173,326**	**2.6**

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
	Class I				
	Andhra Pradesh				
1	Anantapur MCl	19	278	297	1.1
2	Chittoor M	7	238	245	1.6
3	Cuddapah MCl	26	292	318	1.8
4	Eluru M	30	384	414	1.6
5	Guntur MCl	73	863	936	1.5
6	Hindupur M	5	142	147	1.0
7	Kakinada M	15	378	393	1.4
8	Kurnool MCl	27	502	529	1.8
9	Machilipatnam M	9	300	309	1.5
10	Nandyal MCl	5	196	201	1.3
11	Nellore MCl	50	527	577	1.3
12	Nizamabad M	38	366	404	1.3
13	Ongole MCl	15	207	222	1.2
14	Qutubullapur M	5	45	50	0.18
15	Rajahmundry M.Corp.	18	820	838	2.2
16	Tenali M	21	249	270	1.5
17	Tirupati MCl	22	321	343	1.5
18	Vijaywada M.Corp.	43	2,696	2,739	3.2
19	Warangal M.Corp.	57	671	728	0.99
	Bihar				
20	Bihar Sharif M	7	280	287	1.1
21	Chhapra M	16	213	229	1.1
22	Gaya M.Corp.	5	n.a.	n.a.	n.a.
23	Katihar M	4	23	27	0.12
24	Munger M	4	18	22	0.13
25	Ranchi M.Corp.	45	770	815	1.3
	Gujarat				
26	Anand M	4	169	173	0.97
27	Bharuch M	22	698	720	4.4
28	Bhavnagar M.Corp.	4	1,400	1,404	2.5

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
29	Bhuj M	16	150	166	1.3
30	Jamnagar M.Corp.	40	1,260	1,300	2.5
31	Junagadh M	23	369	392	2.2
32	Nadiad M	11	278	289	0.93
33	Navsari M	14	220	234	1.6
34	Porbandar M	10	486	496	3.4
35	Rajkot M.Corp.	26	3,024	3,050	3.0
36	Surendranagar M	4	475	479	3.2
	Haryana				
37	Ambala MCl	18	355	373	3.0
38	Faridabad M.Corp.	46	2,614	2,660	2.3
39	Gurgaon MCl	5	467	472	3.1
40	Hissar MCl	18	573	591	3.1
41	Karnal MCl	5	518	523	3.3
42	Rohtak MCl	4	578	582	2.4
	Jammu & Kashmir				
43	Jammu M.Corp.	11	218	229	0.24
44	Srinagar M.Corp.	n.a.	1,700	1,700	n.a.*
	Karnataka				
45	Belgaum M.Corp.	15	589	604	1.3
46	Bellary CMC	7	225	232	0.76
47	Davangere MCl	10	463	473	1.0
48	Gadag-Betigeri CMC	5	286	291	1.9
49	Gulbarga M.Corp.	14	349	363	0.78
50	Hubli-Dharwad M.Corp.	7	1,163	1,170	1.4
51	Mandya M	4	8	12	0.06
52	Mangalore M.Corp.	18	380	398	0.93
53	Mysore M.Corp.	30	873	903	0.83
54	Shimoga CMC	11	573	584	2.6
55	Tumkur M	20	228	248	1.3

* population covered by the service is not available

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
	Kerala				
56	Alappuzha MC	5	165	170	0.83
57	Kollam MC	26	186	212	0.83
58	Kozhikode M.Corp.	33	670	703	1.4
59	Thalaserry M	8	139	147	1.0
60	Thiruvananthapuram M.Corp.	76	966	1,042	1.7
	Madhya Pradesh				
61	Bhind M	10	147	157	1.9
62	Burhanpur M.Corp.	16	382	398	1.8
63	Dewas M.Corp.	n.a.	674	674	3.4
64	Guna M	9	140	149	1.1
65	Gwalior M.Corp.	158	1,364	1,522	1.5
66	Jabalpur M.Corp.	144	2,064	2,208	2.1
67	Khandwa M	24	584	608	3.3
68	Morena M	3	229	232	1.8
69	Murwara-Katni M.Corp.	54	356	410	2.0
70	Ratlam M.Corp.	38	295	333	1.5
71	Rewa M.Corp.	54	354	408	2.0
72	Satna M.Corp.	41	412	453	2.1
73	Shivpuri M	13	148	161	1.1
	Maharashtra				
74	Amravati M.Corp.	16	837	853	1.7
75	Aurangabad M.Corp.	28	1,718	1,746	2.0
76	Bhusawal M.Cl.	15	307	322	1.8
77	Chandrapur MCl	25	752	777	2.5
78	Dhule MCl	38	750	788	2.3
79	Ichalkaranji MCl	36	724	760	2.9
80	Jalgaon MCl	49	636	685	1.6
81	Kolhapur M.Corp.	71	1,144	1,215	2.3
82	Nanded Waghala M.Corp.	14	477	491	1.2
83	Nashik M.Corp.	38	1,881	1,919	2.2

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
84	Parbhani MCl	4	345	349	1.5
85	Solapur M.Corp.	206	973	1,179	1.1
86	Wardha M	36	322	358	2.1
87	Yavatmal MCl	10	236	246	1.8
	Orissa				
88	Bhubaneswar M.Corp.	38	987	1,025	1.5
89	Cuttack M.Corp.	49	1,431	1,480	2.5
90	Puri M	34	451	485	3.0
91	Rourkela M	22	669	691	3.4
92	Sambalpur M	18	571	589	3.6
	Punjab				
93	Amritsar M.Corp.	18	1,683	1,701	2.1
94	Bathinda MCl	11	602	613	8.7
95	Hoshiarpur MCl	9	252	261	2.3
96	Jalandhar M. Corp.	50	1,490	1,540	2.2
97	Moga MCl	10	546	556	4.6
98	Pathankot MCl	1	230	231	1.2
99	Patiala M.Corp.	15	596	611	1.8
	Rajasthan				
100	Ajmer MCl	8	1,469	1,477	2.7
101	Alwar M	5	350	355	1.3
102	Beawar M	4	314	318	2.2
103	Bhilwara M	31	645	676	2.9
104	Bikaner M	9	869	878	1.4
105	Jodhpur M.Corp.	60	2,525	2,585	2.5
106	Kota M.Corp.	18	n.a.	n.a.	n.a.
107	Sriganganagar M	14	961	975	4.3
	Tamil Nadu				
108	Cuddalore M	31	444	475	2.7
109	Dindigul M	18	451	469	2.1
110	Erode M	35	594	629	3.4

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
111	Kanchipuram M	24	70	94	0.45
112	Kumbakonam M	20	383	403	2.6
113	Nagercoil M	31	383	414	1.9
114	Rajapalaiyam M	19	287	306	2.3
115	Salem M.Corp.	75	1,638	1,713	3.7
116	Thanjavur M	27	542	569	2.5
117	Tiruchirapalli M.Corp.	90	1,959	2,049	2.4
118	Tirunelveli M.Corp.	15	176	191	0.43
119	Tirunvannamalai M	15	144	159	1.1
120	Tiruppur M	n.a.	819	819	2.8
121	Tuticorin M	36	417	453	1.9
122	Vellore M	31	430	461	2.4
	Uttar Pradesh				
123	Agra M.Corp.	109	2,622	2,731	3.0
124	Aligarh M.Corp.	11	n.a.	n.a.	n.a.
125	Allahabad M.Corp.	153	2,345	2,498	2.6
126	Bareilly M.Corp.	16	1,518	1,534	2.0
127	Etawah MB	15	289	304	2.1
128	Faizabad MB	17	400	417	3.4
129	Firozabad MB	10	44	54	0.29
130	Ghaziabad M.Corp.	8	1,147	1,155	1.3
131	Gorakhpur M.Corp.	28	774	802	1.6
132	Haldwani-cum-Kathgodam MB	28	378	406	2.7
133	Hapur MB	17	399	416	2.7
134	Hardwar MB	20	512	532	1.7
135	Jhansi MB	34	700	734	1.8
136	Mathura MB	30	825	855	3.1
137	Meerut M.Corp.	11	1,854	1,865	1.5
138	Mirzapur MB	34	500	534	2.9
139	Moradabad M.Corp.	63	1,001	1,064	2.1
140	Muzaffarnagar MB	20	667	687	2.6
141	Rae Bareli MB	20	531	551	4.0

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
142	Rampur MB	32	485	517	1.5
143	Saharanpur MB	51	985	1,036	3.6
144	Sitapur MB	10	295	305	2.0
145	Unnao MB	11	170	181	1.4
	West Bengal				
146	Asansol M.Corp.	20	487	507	1.5
147	Baharampur M	24	356	380	2.5
148	Balurghat M	2	67	69	0.51
149	Bankura M	23	450	473	3.1
150	Barasat M	6	115	121	1.2
151	Burdwan M	45	650	695	2.4
152	Halisahar M	4	21	25	n.a.*
153	Krishna Nagar M	18	214	232	1.5
154	Midnapur M	34	425	459	2.7
155	North Barrackpur M	n.a.	n.a.	n.a.	n.a.
156	Santipur M	6	170	176	1.3
157	Siliguri M.Corp.	63	140	203	0.44
	Small States				
	Assam				
158	Guwahati M.Corp.	n.a.	492	492	0.35
159	Jorhat MB	6	48	54	0.28
	Manipur				
160	Imphal MCl	18	200	218	0.82
	Meghalaya				
161	Shillong MB	11	375	386	1.7
	Tripura				
162	Agartala MCl	3	85	88	0.43
	Union Territories				
163	Chandigarh M.Corp.	141	1,638	1,779	2.0
164	Pondicherry M	38	677	715	2.3

* population covered by the service is not available

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
	Class II				
	Andhra Pradesh				
1	Anakapalle M	8	40	48	0.35
2	Dharmavaram M	2	72	74	0.72
3	Gudur MCl	1	87	88	1.2
4	Kapra M	8	167	175	1.7
5	Kavali MCl	3	89	92	1.0
6	Madanapalle M	10	131	141	1.3
7	Narasaraopet M	6	138	144	1.6
8	Rajendra Nagar MCl	1	70	71	0.58
9	Sangareddy MCl	1	65	66	1.1
10	Srikakulam MCl	15	165	180	1.7
11	Srikalahasti M	3	110	113	1.6
12	Suryapet MCl	1	100	101	1.1
	Bihar				
13	Buxar M	6	n.a.	n.a.	n.a.
14	Deoghar M	2	27	29	0.27
15	Hajipur M	22	159	181	1.4
16	Hazaribagh M	22	292	314	2.5
17	Jehanabad M	7	68	75	1.4
18	Madhubani M	9	59	68	1.2
19	Mokama M	1	92	93	n.a.*
	Gujarat				
20	Amreli M	18	265	283	3.1
21	Ankleswar M	5	92	97	1.5
22	Dabhoi M	1	62	63	0.95
23	Dohad M	10	118	128	1.5
24	Gondal M	6	185	191	1.9
25	Jetpur M	3	167	170	1.3
26	Mahesana M	4	205	209	1.5
27	Palanpur M	2	307	309	2.6
	Haryana				
28	Jind MCl	7	246	253	3.1
29	Kaithal MCl	9	290	299	3.8

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
30	Rewari MCl	8	243	251	2.3
31	Thanesar MCl	12	192	204	2.7
	Karnataka				
32	Bagalkot CMC	4	102	106	1.2
33	Chikmagalur CMC	5	109	114	1.1
34	Gokak CMC	6	56	62	0.82
35	Hospet CMC	3	173	176	1.5
36	Kolar CMC	11	112	123	1.0
37	Rabkavi-Banhatti CMC	3	56	59	0.78
38	Ramanagaram CMC	6	74	80	1.1
	Kerala				
39	Changanessary MC	3	125	128	2.0
40	Payyanur M	4	16	20	0.23
41	Taliparamba M	5	15	20	0.29
42	Thrissur MC	21	180	201	2.0
	Madhya Pradesh				
43	Hoshangabad M	13	230	243	2.3
44	Itarsi M	12	203	215	1.9
45	Khargone M	26	220	246	2.8
46	Mandsaur M	4	325	329	2.6
47	Nagda M	2	164	166	2.1
48	Neemuch M	11	288	299	2.9
49	Sehore M	6	139	145	1.4
50	Shahdol M	6	107	113	1.4
51	Vidisha M	15	254	269	2.0
	Maharashtra				
52	Amalner MCl	17	385	402	3.9
53	Ballarpur MCl	22	338	360	3.1
54	Bhandara M	9	176	185	2.3
55	Kamptee MCl	16	207	223	2.2
56	Manmad MCl	3	210	213	2.4
57	Ratnagiri MCl	5	76	81	1.1
58	Satara MCl	15	95	110	0.95
59	Virar MCl	2	n.a.	n.a.	n.a.

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
	Punjab				
60	Ferozepur MCl	8	119	127	1.6
61	Kapurthala M	2	200	202	3.8
62	Mansa MCl	2	106	108	1.6
63	Phagwara MCl	4	223	227	2.6
64	Sangrur MCl	2	128	130	2.4
	Rajasthan				
65	Banswara M	18	350	368	3.2
66	Barmer M	6	201	207	2.4
67	Bundi M	7	220	227	2.8
68	Churu M	2	138	140	1.4
69	Hanumangarh M	7	271	278	2.2
70	Sawai Madhopur M	2	184	186	2.1
	Tamil Nadu				
71	Ambur M	14	152	166	1.8
72	Arakkonam M	6	144	150	1.6
73	Attur M	2	84	86	1.3
74	Cumbum M	n.a.	n.a.	n.a.	n.a.
75	Dharmapuri M	9	202	211	3.0
76	Gudiyatham M	4	153	157	1.6
77	Nagapattinam M	16	197	213	1.8
78	Pudukkottai M	10	368	378	3.4
79	Sivakasi M	14	195	209	2.8
80	Srivilliputtur M	4	149	153	2.0
81	Tindivanam M	9	113	122	1.6
82	Udhagamandalam M	11	282	293	2.8
	Uttar Pradesh				
83	Auraiya MB	5	82	87	0.91
84	Balrampur MB	13	150	163	2.5
85	Basti MB	8	165	173	1.7
86	Bhadohi MB	4	77	81	1.5
87	Chandpur MB	5	96	101	2.4
88	Etah MB	7	199	206	2.3
89	Ghazipur MB	7	174	181	2.6
90	Gonda MB	2	216	218	1.9

Status of Municipal Solid Waste Management

C-8: Staff Position, 1999

Sl. No.	City/Town	No. of staff			Staff per 1000 population
		Supervisory	Subordinate	Total	
	1	2	3	4	5
91	Lakhimpur MB	22	229	251	2.3
92	Lalitpur MB	10	146	156	1.6
93	Mughalsarai MB	12	335	347	2.8
94	Nawabganj-Barabanki MB	9	165	174	1.8
95	Orai MB	8	285	293	2.2
96	Roorkee MB	2	15	17	0.18
	West Bengal				
97	Bishnupur M	8	300	308	4.5
98	Chakdaha M	5	27	32	0.60
99	Contai M	18	98	116	1.3
100	Cooch Behar M	30	150	180	1.5
101	Darjeeling M	16	163	179	1.8
102	Jalpaiguri M	38	286	324	2.8
103	Jangipur M	3	10	13	0.15
104	Katwa M	5	212	217	3.1
105	Raniganj M	8	161	169	2.1
	Small States				
	Himachal Pradesh				
106	Shimla M.Corp.	40	490	530	4.4
	Nagaland				
107	Kohima TC	6	80	86	0.78
	Union Territories				
108	Port Blair MCl	12	764	776	7.3
	Others(Smaller than Class II towns)				
	Small States				
	Goa				
109	Panaji MCl	15	125	140	2.2
	Sikkim				
110	Gangtok (Greater Gangtok) NTAC	2	100	102	1.3
	Union Territories				
111	Daman MCl	10	105	115	3.0
112	Silvassa CT	1	35	36	1.8

* population covered by the service is not available

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-9: Privatisation, 1999

Sl. No.	City/Town	Aspect privatised	Details of privatisation					
			Specific area covered	Mode used	Year of privatisation	No. of contractors	Cost before privatisation (Rs in '000)	Cost after privatisation (Rs in '000)
	1	2	3	4	5	6	7	8
	Metropolitan Cities							
1	Bangalore M.Corp.	Sweeping	n.a.	Contract	1989	120	n.a.	n.a.
2	Calcutta M.Corp.	Transportation	-	n.a.	n.a.	n.a.	n.a.	n.a.
3	Chennai M.Corp.	Collection	3 Zones	BOO	Starting 2000	1	n.a.	n.a.
4	Delhi M.Corp.	Composting	n.a.	Contract	1999	1	n.a.	n.a.
5	Greater Mumbai M.Corp.	Transportation	n.a.	Contract	n.a.	n.a.	n.a.	n.a.
6	Hyderabad M.Corp.	Sweeping	n.a.	n.a.	1998	122	n.a.	n.a.
7	Jaipur M.Corp.	Transportation	n.a.	n.a.	1990	18	n.a.	n.a.
8	Ludhiana M.Corp.	Sweeping & collection	n.a.	CBO	n.a.	114	2827	n.a.
9	Madurai M.Corp.	Transportation	Commercial	Contract	1998	2	n.a.	n.a.
10	Nagpur M.Corp.	Collection	n.a.	Contract	1997	2	n.a.	n.a.
11	Surat M.Corp.	Collection & transportation	n.a.	n.a.	n.a.	2	n.a.	n.a.
12	Visakhapatnam M.Corp.	Sweeping & collection	n.a.	n.a.	1994	5	n.a.	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-9: Privatisation, 1999

Sl. No.	City/Town	Aspect privatised	Details of privatisation					
			Specific area covered	Mode used	Year of privatisation	No. of contractors	Cost before privatisation (Rs in '000)	Cost after privatisation (Rs in '000)
	1	2	3	4	5	6	7	8
	Class I							
	Andhra Pradesh							
1	Anantapur MCl	Sweeping	n.a.	Contract	1997	1	11500	14500
2	Chittoor M	Sweeping & collection	n.a.	Contract	1999	1	n.a.	n.a.
3	Eluru M	Collection & disposal	n.a.	Contract	1998	2	n.a.	1800
4	Guntur MCl	Collection & disposal	n.a.	Contract	1996	3	n.a.	3864
5	Hindupur M	Sweeping & collection	n.a.	Contract	1996	1	n.a.	100
6	Nandyal MCl	Sweeping	n.a.	NGO	1998	1	n.a.	n.a.
7	Nellore MCl	Sweeping	n.a.	Contract	1998	5	23843	27812
8	Qutubullapur M	Sweeping	n.a.	Contract	1997	5	2000	4200
9	Tenali M	Collection & disposal	n.a.	Contract	1998	1	n.a.	144
10	Tirupati MCl	Sweeping & collection	n.a.	Contract	1997	4	n.a.	n.a.
11	Vijaywada M.Corp.	Disposal & treatment	n.a.	n.a.	n.a.	3	n.a.	n.a.
	Bihar							
12	Gaya M.Corp.	Drain cleaning	n.a.	Contract	1999	4	n.a.	740
	Gujarat							
13	Bhuj M	Collection & transportation	-	-	-	-	-	-
14	Jamnagar M.Corp.	Primary collection	n.a.	Contract	1987	6	8000	2200
15	Rajkot M.Corp.	Collection & transportation	n.a.	Contract	1990	9	n.a.	7000
	Jammu & Kashmir							
16	Srinagar M.Corp.	Collection	New colonies	Contract	1999	3	n.a.	n.a.
	Karnataka							
17	Belgaum M.Corp.	Transportation	n.a.	Contract	1994	2	n.a.	n.a.
18	Bellary CMC	Sweeping & transportation	n.a.	Contract	1998	2	n.a.	n.a.
19	Davangere MCl	Composting	n.a.	Auction	1996	55	n.a.	n.a.
20	Hubli-Dharwad M.Corp.	Vermi-composting	n.a.	Contract	1998	1	n.a.	n.a.
21	Mysore M.Corp.	Sweeping & transportation	n.a.	Contract	1998	7	n.a.	n.a.
22	Shimoga CMC	Disposal	12 wards	Contract	1994	6	n.a.	n.a.

Status of Municipal Solid Waste Management

C-9: Privatisation, 1999

Sl. No.	City/Town	Aspect privatised	Details of privatisation					
			Specific area covered	Mode used	Year of privatisation	No. of contractors	Cost before privatisation (Rs in '000)	Cost after privatisation (Rs in '000)
	1	2	3	4	5	6	7	8
	Kerala							
23	Alappuzha MC	Disposal	n.a.	Contract	1999	1	n.a.	n.a.
	Madhya Pradesh							
24	Jabalpur M.Corp.	Sweeping	n.a.	Contract	1998	1	1164	770
	Maharashtra							
25	Amravati M.Corp.	Sweeping	n.a.	Contract	1985	2	n.a.	700
26	Aurangabad M.Corp.	Composting	entire town	Contract	1997	1	n.a.	30000
27	Nanded Waghala M.Corp.	Sweeping	entire city	Contract	1997	1	n.a.	1000
28	Nashik M.Corp.	Transportation	n.a.	Contract	1997	77	n.a.	26500
29	Parbhani MCl	Transportation	n.a.	Contract	1999	2	n.a.	1205
	Orissa							
30	Bhubaneswar M.Corp.	Collection	n.a.	Contract	n.a.	n.a.	n.a.	n.a.
	Rajasthan							
31	Ajmer MCl	Transportation	entire town	n.a.	1998	2	n.a.	n.a.
32	Sriganganagar M	Sweeping	entire town	Contract	1994	3	700	350
	Tamil Nadu							
33	Tiruppur M	Secondary collection	Major roads	Contract	1997	1	n.a.	n.a.
	West Bengal							
34	Asansol M.Corp.	Primary collection & transportation	n.a.	Contract	n.a.	7	n.a.	n.a.
	Small States							
	Assam							
35	Guwahati M.Corp.	Transportation	entire city	Contract	1988	13	n.a.	n.a.
	Tripura							
36	Agartala MCl	Composting	n.a.	n.a.	1999	n.a.	n.a.	n.a.
	Union Territories							
37	Chandigarh M.Corp.	Sweeping & collection	n.a.	Contract	1996	3	n.a.	2720
38	Pondicherry M	Sweeping & collection	n.a.	Contract	1997	1	n.a.	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-9: Privatisation, 1999

Sl. No.	City/Town	Aspect privatised	Details of privatisation					
			Specific area covered	Mode used	Year of privatisation	No. of contractors	Cost before privatisation (Rs in '000)	Cost after privatisation (Rs in '000)
	1	2	3	4	5	6	7	8
	Class II							
	Andhra Pradesh							
1	Kapra M	Sweeping	n.a.	n.a.	1999	3	4640	2908
2	Madanapalle M	Sweeping & collection	n.a.	Contract	n.a.	2	n.a.	97
3	Narasaraopet M	Collection & disposal	n.a.	Contract	1998	1	n.a.	1248
4	Rajendra Nagar MCl	Sweeping & collection	n.a.	NGO	1997	1	20	85
5	Srikalahasti M	Sweeping & collection	n.a.	Contract	1998	n.a.	n.a.	-
6	Suryapet MCl	Sweeping & collection	n.a.	Contract	1997	2	n.a.	n.a.
	Karnataka							
7	Bagalkot CMC	Sweeping	n.a.	Contract	1999	2	n.a.	n.a.
8	Chikmagalur CMC	Collection & transportation	entire town	Contract	1997	1	n.a.	n.a.
9	Gokak CMC	Sweeping & transportation	n.a.	n.a.	1999	1	n.a.	n.a.
10	Rabkavi-Banhatti CMC	Transportation	n.a.	Auction	n.a.	n.a.	n.a.	n.a.
	Maharashtra							
11	Bhandara M	Nala cleaning	n.a.	n.a.	1999	1	n.a.	n.a.
12	Kamptee MCl	Sweeping & collection	commercial	Contract	1999	1	25	18
13	Manmad MCl	Transportation	n.a.	Contract	1999	1	300	147
14	Virar MCl	Sweeping & collection	entire town	Contract	1999	1	4500	3500
	Others(Smaller than Class II towns)							
	Small States							
	Goa							
15	Panaji MCl	Collection, transportation & disposal	Restaurants	Contract	1995	2	n.a.	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-10: Revenue Receipts for Solid Waste Management, 1997-98

Sl. No.	City/Town	Rates of sanitation		Revenue Receipts (Rs. in '000)				
		Unit	Rate (%)	Sanitation tax/ cess	Sale of compost	Sale of rubbish	Others	Total
	1	2	3	4	5	6	7	8
	Metropolitan Cities							
1	Ahmedabad M.Corp.	-	-	-	91	-	1,984	2,075
2	Bhopal M.Corp.	-	-	-	80	-	-	80
3	Delhi M.Corp.	-	-	-	n.a.	-	6900*	6,900
4	Chennai M.Corp.							2,755,700
5	Greater Mumbai M.Corp.	-	-	-	-	-	80000**	80,000
6	Lucknow M.Corp.	-	-	-	-	102	-	102
7	Nagpur M.Corp.	n.a.	n.a.	48,300	-	-	-	48,300
8	Pune M.Corp.	% of arv	13	116,600	-	-	-	116,600
9	Surat M.Corp.^	% of arv	6, 12, 24	12,622				12,622

* Private removal charges (54 lakh) and Other receipts (15 lakh) ; ** Administration Charges

arv = Annual rateable value ; ^ Different rates of sanitation are for residential, non-residential and commercial respectively in Surat M.Corp

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-10: Revenue Receipts for Solid Waste Management, 1997-98

Sl. No.	City/Town	Rates of sanitation		Revenue Receipts (Rs. in '000)				
		Unit	Rate (%)	Sanitation tax/ cess	Sale of compost	Sale of rubbish	Others	Total
	1	2	3	4	5	6	7	8
	Class I							
	Andhra Pradesh							
1	Eluru M	n.a.	n.a.	1,522	5	-	107	1,634
2	Vijaywada M.Corp.	-	-	-	-	-	1,500	1,500
	Bihar							
3	Bihar Sharif M	% of arv	8	1,480	-	-	-	1,480
	Gujarat							
4	Bhavnagar M.Corp.	% of arv	9	14,916	-	-	-	14,916
5	Jamnagar M.Corp.	n.a.	n.a.	5,529	-	-	177	5,706
6	Navsari M	% of arv	4	2,056	-	-	-	2,056
7	Porbandar M	-	-	-	39	-	-	39
8	Rajkot M.Corp.	% of arv	4-10	26,451	-	-	-	26,451
9	Surendranagar M	-	-	-	-	-	74	74
	Karnataka							
10	Gadag-Betigeri CMC	-	-	-	2	-	-	2
11	Gulbarga M.Corp.	n.a.	n.a.	121	-	-	-	121
12	Mysore M.Corp.	-	-	-	-	187	-	187
13	Shimoga CMC	n.a.	n.a.	2,080	-	-	-	2,080
14	Tumkur M	n.a.	n.a.	693	-	-	-	693
	Madhya Pradesh							
15	Burhanpur M.Corp.	-	-	-	103	-	-	103
16	Guna M	-	-	-	5	-	-	5
17	Jabalpur M.Corp.	Rs./year	180	1,489	-	-	2,595	4,084
18	Khandwa M	0	0	-	48	-	-	48
19	Morena M	Rs./year	150	384	-	-	-	384
20	Murwara-Katni M.Corp.	n.a.	n.a.	70	-	16	628	714
21	Satna M.Corp.	-	-	-	-	2	-	2
	Maharashtra							
22	Amravati M.Corp.	% of arv	24	36	7	-	-	43
23	Aurangabad M.Corp.	% of arv	1	6,481	-	-	-	6,481
24	Bhusawal M.Cl.	n.a.	n.a.	2,366	-	-	-	2,366
25	Ichalkaranji MCl	-	-	-	18	-	-	18
26	Kolhapur M.Corp.	% of arv	30	16,507	-	-	-	16,507
27	Nanded Waghala M.Corp.	n.a.	n.a.	845	-	-	-	845
28	Nashik M.Corp.	% of arv	5	7,049	-	-	-	7,049
29	Parbhani MCl	-	-	-	-	27	-	27
30	Solapur M.Corp.	n.a.	n.a.	14,662	204	-	-	14,866

Status of Municipal Solid Waste Management

C-10: Revenue Receipts for Solid Waste Management, 1997-98

Sl. No.	City/Town	Rates of sanitation		Revenue Receipts (Rs. in '000)				
		Unit	Rate (%)	Sanitation tax/ cess	Sale of compost	Sale of rubbish	Others	Total
	1	2	3	4	5	6	7	8
	Tamil Nadu							
31	Dindigul M	-	-	-	-	113	-	113
32	Kanchipuram M	n.a.	n.a.	1,657	-	-	2,558	4,215
33	Salem M.Corp.	% of arv	1	4,126	-	-	-	4,126
34	Thanjavur M	-	-	-	146	-	-	146
35	Tiruchirapalli M.Corp.	% of arv	2	7,811	-	-	-	7,811
36	Tirunelveli M.Corp.	-	-	-	-	6	-	6
37	Tirunvannamalai M	-	-	-	2	-	-	2
38	Tiruppur M	% of arv	2	2,737	-	-	-	2,737
39	Tuticorin M	-	-	-	-	1	-	1
	Uttar Pradesh							
40	Agra M.Corp.	-	-	-	-	-	99	99
41	Bareilly M.Corp.	-	-	-	-	300	-	300
42	Etawah MB	-	-	-	21	-	-	21
43	Haldwani-cum-Kathgodam	% of arv	10	3,000	-	n.a.	-	3,000
44	Jhansi MB	-	-	-	11	26	-	37
45	Rampur MB	-	-	-	21	-	-	21
46	Saharanpur MB	n.a.	n.a.	1,005	-	-	-	1,005
	West Bengal							
47	Balurghat M	-	-	-	4	-	-	4
48	Baharampur M	-	-	-	5	-	-	5
49	Krishna Nagar M	-	-	-	-	-	34	34
50	Midnapur M	-	-	-	38	-	-	38
51	North Barrackpur M	-	-	-	-	-	86	86
52	Santipur M	-	-	-	12	-	-	12
	Small States							
	Assam							
53	Guwahati M.Corp.	*% of arv	3	4,962	-	-	-	4,962
	Meghalaya							
54	Shillong MB	% of arv	variable	1,674	-	-	-	1,674
	Tripura							
55	Agartala MCl	% of arv	3	90	-	-	-	90
	Union Territories							
56	Pondicherry M	-	-	-	20	-	-	20

arv = Annual rateable value

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-10: Revenue Receipts for Solid Waste Management, 1997-98

Sl. No.	City/Town	Rates of sanitation		Revenue Receipts (Rs. in '000)				
		Unit	Rate (%)	Sanitation tax/ cess	Sale of compost	Sale of rubbish	Others	Total
	1	2	3	4	5	6	7	8
	Class II							
	Andhra Pradesh							
1	Dharmavaram M	-	-	0	57	0	0	57
2	Gudur MCl	-	-	0	0	0	12	12
3	Kapra M	*% of arv	2	548	0	0	0	548
4	Kavali MCl	-	-	0	27	0	0	27
5	Suryapet MCl	% of arv	2	493	0	0	0	493
	Karnataka							
6	Chikmagalur CMC	n.a.	n.a.	1,050	0	0	0	1,050
7	Rabkavi-Banhatti CMC	% of arv	10	130	166	0	0	296
8	Ramanagaram CMC	n.a.	n.a.	173	0	0	0	173
	Kerala							
9	Payyanur M	n.a.	n.a.	745	0	0	0	745
10	Taliparamba M	% of arv	3	110	0	0	0	110
	Madhya Pradesh							
11	Hoshangabad M	Rs./year	150	97	0	0	0	97
12	Itarsi M	Rs./year	150	331	0	0	0	331
13	Khargone M	0	0	0	17	0	0	17
14	Mandsaur M	Rs./year	150	705	3	0	0	708
15	Neemuch M	Rs./year	50	n.a.	51	0	0	51
	Tamil Nadu							
16	Attur M	0	0	0	0	3	0	3
17	Cumbum M	0	0	0	9	0	0	9
	Uttar Pradesh							
18	Etah MB	0	0	0	0	0	20	20
19	Lalitpur MB	0	0	0	5	0	0	5
20	Roorkee MB	0	0	0	1	0	0	1
	West Bengal							
21	Darjeeling M	n.a.	n.a.	194	0	0	0	194
22	Raniganj M	0	0	0	0	280	0	280

arv = Annual rateable value

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Metropolitan Cities						
1	Ahmedabad M.Corp.	316,242	10,707	17	0	19,188	346,154
2	Bangalore M.Corp.	279,700	8,778	124,112	0	9,800	422,390
3	Bhopal M.Corp.	13,005	n.a.	0	0	0	13,005
4	Calcutta M.Corp.	Break-up not available					794,309
5	Chennai M.Corp.	455,467	37,270	39,071	28,983	32,895	593,686
6	Coimbatore M.Corp.	168,515	4,606	0	0	0	173,121
7	Delhi M.Corp.	1,392,200	0	0	11,935	66,720	1,470,855
8	Greater Mumbai M.Corp.	2,750,000	50,000	200,000	750,000	0	3,750,000
9	Hyderabad M.Corp.	250,000	0	0	25,000	0	275,000
10	Indore M.Corp.	n.a					
11	Jaipur M.Corp.	257,241	25,782	0	0	54,000	337,023
12	Kanpur M.Corp.	227,326	43,515	0	0	0	270,841
13	Kochi M.Corp.	18,770	2,420	0	0	0	21,190
14	Lucknow M.Corp.	21,000	12,000	4,000	0	0	37,000
15	Ludhiana M.Corp.	132,773	380	0	0	0	133,153
16	Madurai M.Corp.	101,751	14	378	10,027	0	112,170
17	Nagpur M.Corp.	158,755	8,755	3,266	0	0	170,776
18	Pune M.Corp.	233,314	n.a.	0	224	0	233,538
19	Surat M.Corp.	11,855	55,617	0	0	0	67,472
20	Vadodara M.Corp.	4,112	718	1,354	13	0	6,197
21	Varanasi M.Corp.	234,293	10,463	6,126	0	0	250,883
22	Visakhapatnam M.Corp.	144,370	0	0	0	17,630	162,000

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Class I						
	Andhra Pradesh						
1	Anantapur MCl	8,998	950	230	1,030	0	11,208
2	Chittoor M	950	500	39	0	600	2,089
3	Cuddapah MCl	9,000	300	384	120	0	9,804
4	Eluru M	11,853	260	300	2,036	1,080	15,529
5	Guntur MCl	30,100	0	0	0	2,948	33,048
6	Hindupur M	5,224	200	150	0	60	5,634
7	Kakinada M	9,443	600	300	0	732	11,075
8	Kurnool MCl	9,256	0	0	0	973	10,229
9	Machilipatnam M	14,400	250	0	0	0	14,650
10	Nandyal MCl	700	325	100	400	500	2,025
11	Nellore MCl	24,868	1,311	471	1,994	0	28,643
12	Nizamabad M	20,400	0	0	0	0	20,400
13	Ongole MCl	8,697	200	169	2,170	0	11,236
14	Qutubullapur M	150	50	30	500	2,400	3,130
15	Rajahmundry M.Corp.	20,897	514	130	0	6,300	27,841
16	Tenali M	3,671	0	90	1,516	0	5,277
17	Tirupati MCl	9,333	3,806	0	0	0	13,139
18	Vijaywada M.Corp.	62,147	6,500	1,300	1,300	6,400	77,647
19	Warangal M.Corp.	2,073	0	182	3,262	0	5,517
	Bihar						
20	Bihar Sharif M	6,121	136	150	10	0	6,417
21	Chhapra M	Break-up not available					14,660
22	Gaya M.Corp.	150	0	0	0	0	150
23	Katihar M	8,113	109	121	6	0	8,349
24	Munger M	n.a.					
25	Ranchi M.Corp.	30,000	800	200	0	0	31,000
	Gujarat						
26	Anand M	n.a.					
27	Bharuch M	23,346	1,410	875	477	567	26,675
28	Bhavnagar M.Corp.	60,000	500	200	0	3,500	64,200
29	Bhuj M	7,426	0	372	0	2,698	10,495
30	Jamnagar M.Corp.	45,421	0	0	335	0	45,756
31	Junagadh M	11,888	0	0	0	1,560	13,448
32	Nadiad M	13,780	413	187	0	0	14,380

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
33	Navsari M	6,636	4,244	0	0	0	10,881
34	Porbandar M	11,503	0	0	434	0	11,937
35	Rajkot M.Corp.	81,376	9,201	0	0	1,773	92,350
36	Surendranagar M	11,506	0	10	0	0	11,516
	Haryana						
37	Ambala MCl	12,741	199	53	48	0	13,041
38	Faridabad M.Corp.	249,890	4,574	2,243	0	0	256,707
39	Gurgaon MCl	17,815	552	0	0	0	18,367
40	Hissar MCl	1,239	247	493	0	0	1,979
41	Karnal MCl	20,380	612	0	0	0	20,992
42	Rohtak MCl	18,926	411	298	425	0	20,060
	Jammu & Kashmir						
43	Jammu M.Corp.	n.a.					
44	Srinagar M.Corp.	14,500	130	2,000	2,000	0	18,630
	Karnataka						
45	Belgaum M.Corp.	30,483	1,237	437	1,126	2,881	36,164
46	Bellary CMC	14,721	1,486	559	2,710	138	19,614
47	Davangere MCl	20,478	1,010	260	249	0	21,997
48	Gadag-Betigeri CMC	10,733	344	40	0	0	11,117
49	Gulbarga M.Corp.	16,188	703	124	2,230	3,163	22,408
50	Hubli-Dharwad M.Corp.	55,776	1,945	876	2,112	2,182	62,891
51	Mandya M	12,417	261	56	76	30	12,840
52	Mangalore M.Corp.	12,246	1,787	1,538	45	5,575	21,191
53	Mysore M.Corp.	42,729	3,468	1,064	2,214	475	49,950
54	Shimoga CMC	30,240	1,262	868	0	475	32,845
55	Tumkur M	3,547	57	40	0	0	3,644
	Kerala						
56	Alappuzha MC	11,761	265	0	1,087	0	13,113
57	Kollam MC	15,655	0	0	162	0	15,817
58	Kozhikode M.Corp.	34,737	1,530	0	2,541	0	38,808
59	Thalaserry M	8,841	419	768	0	0	10,028
60	Thiruvananthapuram M.Corp.	47,198	8,313	0	688	0	56,199
	Madhya Pradesh						
61	Bhind M*	5,612	202	168	3	116	6,101
62	Burhanpur M.Corp.	14,062	1,224	0	0	0	15,286

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
63	Dewas M.Corp.	16,390	449	0	121	1,005	17,964
64	Guna M	4,800	3,300	125	450	0	8,675
65	Gwalior M.Corp.	5,984	1,899	625	0	0	8,508
66	Jabalpur M.Corp.	75,716	0	257	625	8,784	85,383
67	Khandwa M	16,938	256	96	0	0	17,290
68	Morena M	n.a.					
69	Murwara-Katni M.Corp.	14,954	327	220	135	55	15,691
70	Ratlam M.Corp.	14,750	203	0	99	0	15,051
71	Rewa M.Corp.	12,700	420	50	50	0	13,220
72	Satna M.Corp.	7,112	706	210	0	0	8,028
73	Shivpuri M	5,700	360	312	120	0	6,492
	Maharashtra						
74	Amravati M.Corp.	34,760	0	0	0	1,050	35,810
75	Aurangabad M.Corp.	54,678	3,041	5,631	644	542	64,536
76	Bhusawal M.Cl.	10,498	701	194	1,482	0	12,875
77	Chandrapur MCl	18,007	2,003	0	1,471	1,007	22,487
78	Dhule MCl	21,091	780	100	10	60	22,041
79	Ichalkaranji MCl	1,263	149	171	0	0	1,583
80	Jalgaon MCl	26,469	0	808	0	5,292	32,569
81	Kolhapur M.Corp.	43,865	1,279	0	0	3,158	48,301
82	Nanded Waghala M.Corp.	22,737	642	1,019	491	1,326	26,215
83	Nashik M.Corp.	8,857	0	0	120	0	8,977
84	Parbhani MCl	8,801	406	403	116	80	9,806
85	Solapur M.Corp.	10,076	2,465	2,438	187	844	16,010
86	Wardha M	10,987	164	901	682	0	12,735
87	Yavatmal MCl	7,404	271	283	2,984	0	10,942
	Orissa						
88	Bhubaneswar M.Corp.	n.a					
89	Cuttack M.Corp.	n.a					
90	Puri M	n.a					
91	Rourkela M	n.a					
92	Sambalpur M	n.a					
	(* Figures for Bhind are for 1996-97)						

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Punjab						
93	Amritsar M.Corp.	96,770	9,400	2,471	1,533	0	110,174
94	Bathinda MCl	2,700	730	600	500	0	4,530
95	Hoshiarpur MCl	12,726	95	102	332	0	13,255
96	Jalandhar M. Corp.	107,320	9,125	2,250	0	0	118,695
97	Moga MCl	4,500	600	100	200	0	5,400
98	Pathankot MCl	12,157	350	350	77	0	12,934
99	Patiala M.Corp.	22,500	1,650	0	0	0	24,150
	Rajasthan						
100	Ajmer MCl	127,000	140,000	0	0	0	267,000
101	Alwar M	16,652	0	0	5,555	525	22,731
102	Beawar M	13,230	285	325	278	940	15,058
103	Bhilwara M	47,595	5,041	0	0	41,024	93,660
104	Bikaner M	48,607	761	407	6,678	0	56,453
105	Jodhpur M.Corp.	118,046	3,755	0	0	5,784	127,585
106	Kota M.Corp.	n.a.					
107	Sriganganagar M	18,793	12	796	0	0	19,601
	Tamil Nadu						
108	Cuddalore M	10,577	0	0	751	0	11,328
109	Dindigul M	16,053	0	0	601	0	16,654
110	Erode M	18,464	0	0	3,014	0	21,478
111	Kanchipuram M	965	0	0	1,735	5,595	8,295
112	Kumbakonam M	12,635	0	1,594	0	0	14,229
113	Nagercoil M	14,592	0	0	39	0	14,631
114	Rajapalaiyam M	11,670	1,016	0	0	0	12,686
115	Salem M.Corp.	49,690	10,993	7,207	3,472	0	71,362
116	Thanjavur M	17,298	0	0	38	0	17,336
117	Tiruchirapalli M.Corp.	64,792	4,721	0	0	0	69,513
118	Tirunelveli M.Corp.	28,905	0	0	218	0	29,123
119	Tirunvannamalai M	9,972	1,184	0	805	0	11,961
120	Tiruppur M	26,901	4,890	0	0	0	31,791
121	Tuticorin M	21,952	0	0	1,144	0	23,096
122	Vellore M	13,576	0	0	824	0	14,400

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Uttar Pradesh						
123	Agra M.Corp.	120,368	9,966	0	0	0	130,334
124	Aligarh M.Corp.	7,000	600	400	0	0	8,000
125	Allahabad M.Corp.	119,651	16,643	0	0	0	136,294
126	Bareilly M.Corp.	60,000	2,448	830	0	0	63,278
127	Etawah MB	2,200	2,400	25	0	0	4,625
128	Faizabad MB	20,400	240	50	0	0	20,690
129	Firozabad MB	21,869	7,150	0	0	96	29,114
130	Ghaziabad M.Corp.	61,511	0	0	0	19,580	81,090
131	Gorakhpur M.Corp.	34,658	4,517	0	0	0	39,174
132	Haldwani-cum-Kathgodam MB	25,200	0	100	50	0	25,350
133	Hapur MB	11,869	0	548	0	0	12,417
134	Hardwar MB	36,408	1,572	0	0	0	37,980
135	Jhansi MB	22,567	1,081	287	51	62	24,048
136	Mathura MB	28,174	641	29	121	0	28,965
137	Meerut M.Corp.	81,029	12,150	0	0	13,064	106,243
138	Mirzapur MB	36,473	Expenditure on other heads not available				36,473
139	Moradabad M.Corp.	n.a.					
140	Muzaffarnagar MB	36,631	688	252	1,762	0	39,333
141	Rae Bareli MB	Break-up not available					31,280
142	Rampur MB	16,707	3,098	0	0	0	19,805
143	Saharanpur MB	40,355	6,748	0	0	0	47,103
144	Sitapur MB	596	0	0	0	11,824	12,419
145	Unnao MB	Break-up not available					5,079
	West Bengal						
146	Asansol M.Corp.	7,192	0	0	0	6,534	13,726
147	Baharampur M	14,236	174	120	0	0	14,531
148	Balurghat M	1,620	565	100	15	0	2,300
149	Bankura M	12,927	232	105	48	0	13,312
146	Barasat M	3,893	0	435	0	0	4,327
150	Burdwan M	n.a.					
151	Halisahar M	n.a.					
152	Krishna Nagar M	11,613	329	0	321	66	12,328
153	Midnapur M	11,000	250	80	2,000	675	14,005
154	North Barrackpur M	3,955	155	58	14	290	4,472

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
155	Santipur M	4,337	144	141	2	0	4,624
156	Siliguri M.Corp.	20,417	0	0	0	5,333	25,749
	Small States						
	Assam						
157	Guwahati M.Corp.	15,600	3,600	4,320	1,200	0	24,720
158	Jorhat MB	n.a.					
	Manipur						
159	Imphal MCl	4,662	378	631	0	0	5,670
160	**Meghalaya**						
161	Shillong MB	7,780	467	99	149	137	8,632
	Tripura						
162	Agartala MCl	7,875	1,150	1,100	300	0	10,425
	Union Territories						
163	Chandigarh M.Corp.	97,004	4,007	2,410	9,593	0	113,014
164	Pondicherry M	22,469	238	694	94	0	23,495

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Class II						
	Andhra Pradesh						
1	Anakapalle M	300	120	60	0	0	480
2	Dharmavaram M	n.a.					
3	Gudur MCl	3,000	96	90	0	0	3,186
4	Kapra M	5,577	89	131	0	0	5,797
5	Kavali MCl	3,943	165	135	64	0	4,307
6	Madanapalle M	5,199	450	0	800	0	6,449
7	Narasaraopet M	2,722	90	50	30	559	3,451
8	Rajendra Nagar MCl	n.a.					
9	Sangareddy MCl	2,686	112	54	0	485	3,337
10	Srikakulam MCl	n.a.					
11	Srikalahasti M	Break-up not available					4,177
12	Suryapet MCl	3,844	166	53	338	973	5,374
	Bihar						
13	Buxar M	n.a.					
14	Deoghar M	88	94	14	0	0	197
15	Hajipur M	3,153	45	20	0	91	3,309
16	Hazaribagh M	n.a.					
17	Jehanabad M	1,771	30	25	15	0	1,842
18	Madhubani M	1,721	19	20	11	0	1,772
19	Mokama M	n.a.					
	Gujarat						
20	Amreli M	714	87	299	0	0	1,100
21	Ankleswar M	3,575	87	443	0	32	4,137
22	Dabhoi M	2,854	0	0	0	156	3,010
23	Dohad M	n.a.					
24	Gondal M	8,581	290	0	0	0	8,872
25	Jetpur M	7,118	153	822	18	0	8,111
26	Mahesana M	4,743	345	656	358	0	6,103
27	Palanpur M	10,363	564	124	26	0	11,077
	Haryana						
28	Jind MCl	8,176	63	109	68	0	8,416
29	Kaithal MCl	8,352	85	50	24	0	8,511

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
30	Rewari MCl	12,199	99	25	180	0	12,504
31	Thanesar MCl	7,973	81	74	305	0	8,433
	Karnataka						
32	Bagalkot CMC	4,473	258	97	486	0	5,314
33	Chikmagalur CMC	4,685	0	0	0	600	5,285
34	Gokak CMC	1,973	89	133	0	0	2,195
35	Hospet CMC	n.a					
36	Kolar CMC	4,284	2,275	1,806	0	2,000	10,365
37	Rabkavi-Banhatti CMC	2,629	308	8	0	0	2,945
38	Ramanagaram CMC	2,199	0	0	0	647	2,846
	Kerala						
39	Changanessary MC	5,948	268	0	0	470	6,686
40	Payyanur M	1,070	12	40	2	0	1,124
41	Taliparamba M	428	0	100	0	0	528
42	Thrissur MC	13,356	1,133	0	0	0	14,489
	Madhya Pradesh						
43	Hoshangabad M	1,528	311	197	267	1,762	4,065
44	Itarsi M	5,147	576	46	0	0	5,769
45	Khargone M	4,468	0	1,429	0	0	5,897
46	Mandsaur M	8,826	532	164	2,510	23	12,055
47	Nagda M	4,290	154	491	72	0	5,007
48	Neemuch M	7,945	848	0	239	212	9,243
49	Sehore M	5,655	417	22	24	0	6,119
50	Shahdol M	2,636	116	179	0	0	2,932
51	Vidisha M	7,109	243	203	0	92	7,648
	Maharashtra						
52	Amalner MCl	n.a.					
53	Ballarpur MCl	9,265	170	292	62	44	9,833
54	Bhandara M	5,448	125	172	1,124	0	6,869
55	Kamptee MCl	7,362	47	50	14	0	7,473
56	Manmad MCl	8,800	1,200	350	0	0	10,350
57	Ratnagiri MCl	4,352	105	164	1,420	0	6,040
58	Satara MCl	6,805	1,017	200	0	0	8,021
59	Virar MCl	n.a.					

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
	Punjab						
60	Ferozepur MCl	4,800	216	54	32	0	5,102
61	Kapurthala M	8,367	265	95	290	0	9,017
62	Mansa MCl	13,469	307	80	70	0	13,926
63	Phagwara MCl	8,403	500	80	320	0	9,303
64	Sangrur MCl	6,138	0	200	300	167	6,805
	Rajasthan						
65	Banswara M	1,600	240	120	40	0	2,000
66	Barmer M	8,705	147	130	775	0	9,756
67	Bundi M	1,500	250	50	0	0	1,800
68	Churu M	8,362	415	0	0	10	8,787
69	Hanumangarh M	13,787	935	0	0	0	14,722
70	Sawai Madhopur M	n.a.					
	Tamil Nadu						
71	Ambur M	5,510	0	106	0	0	5,616
72	Arakkonam M	4,307	0	192	0	0	4,499
73	Attur M	4,952	0	0	147	0	5,099
74	Cumbum M	Break-up not available					427
75	Dharmapuri M	7,471	211	0	1,070	867	9,619
76	Gudiyatham M	4,907	0	0	35	0	4,942
77	Nagapattinam M	7,501	0	0	182	0	7,683
78	Pudukkottai M	12,888	0	1,447	0	0	14,335
79	Sivakasi M	7,996	n.a.	n.a.	69	n.a	8,065
80	Srivilliputtur M	6,122	86	0	0	0	6,208
81	Tindivanam M	5,913	0	0	498	0	6,411
82	Udhagamandalam M	10,956	0	0	59	0	11,015
	Uttar Pradesh						
83	Auraiya MB	4,145	37	59	0	0	4,241
84	Balrampur MB	Break-up not available					5,407
85	Basti MB	5,686	767	0	0	0	6,453
86	Bhadohi MB	6,742	64	39	0	4,235	11,080
87	Chandpur MB	7,437	52	19	0	0	7,508
88	Etah MB	10,033	2,372	0	5,528	0	17,933
89	Ghazipur MB	8,960	2,660	0	0	0	11,620
90	Gonda MB	1,010	432	98	0	0	1,540

Status of Municipal Solid Waste Management

C-11: Expenditure on Solid Waste Management, 1997-98

Sl. No.	City/Town	Revenue Expenditure (Rs. in '000)					
		Salary and wages	Consumables	Vehicle repair	Contingency	Others	Total
	1	2	3	4	5	6	7
91	Lakhimpur MB	9,398	29	110	0	0	9,537
92	Lalitpur MB	5,948	71	21	3	35	6,078
93	Mughalsarai MB	13,756	40,946	0	0	0	54,703
94	Nawabganj-Barabanki MB	8,350	200	495	0	0	9,045
95	Orai MB	8,926	171	0	0	0	9,097
96	Roorkee MB	498	254	51	0	0	803
	West Bengal						
97	Bishnupur M	4,058	365	180	0	0	4,603
98	Chakdaha M	980	30	18	0	0	1,028
99	Contai M	2,809	24	33	24	0	2,889
100	Cooch Behar M	7,053	392	334	33	0	7,811
101	Darjeeling M	9,829	327	0	0	0	10,156
102	Jalpaiguri M	9,530	486	386	28	0	10,430
103	Jangipur M	540	26	10	0	0	576
104	Katwa M	3,791	152	146	70	0	4,159
105	Raniganj M	3,239	133	221	27	0	3,619
	Small States						
	Himachal Pradesh						
106	Shimla M.Corp.	25,415	1,042	648	0	20,986	48,091
	Nagaland						
107	Kohima TC	n.a.					
	Union Territories						
108	Port Blair MCl	n.a.					
	Others(Smaller than Class II towns)						
	Small States						
	Goa						
109	Panaji MCl	14,529	719	494	0	0	15,741
	Sikkim						
110	Gangtok (Greater Gangtok) NTAC	1,100	400	0	0	0	1,500
	Union Territories						
111	Daman MCl	2,378	107	576	0	0	3,060
112	Silvassa CT	n.a.					

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-12: Capital Works Undertaken between 1994 and 1999

Sl. No.	City/Town	Component	Purpose	Year started	Year completed	Total Cost (Rs. in '000)	Source of funding
	1	2	3	4	5	6	7
	Metropolitan Cities						
1	Ahmedabad M.Corp.	Purchase of equipment	Waste collection	1996	1998	11,901	Self financed
2	Delhi M.Corp.	Purchase of vehicles/ equipment	Improving transportation	1994	1999	530,300	State govt.
3	Greater Mumbai M.Corp.	Purchase of vehicles/ equipment	Waste collection	1997	1999	30,000	n.a.
4	Kochi M.Corp.	Acquiring land	Treatment of waste	1998	-	n.a.	HUDCO
		Purchase of vehicles	Waste disposal	1995	1995	n.a.	Self/ State govt.
5	Ludhiana M.Corp.	n.a.	-	-	-	-	-
6	Nagpur M.Corp.	Purchase of equipment	Waste collection	1997	ongoing	30,000	State govt.
7	Pune M.Corp.	Purchase of equipment	Waste collection	n.a.	-	n.a.	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-12: Capital Works Undertaken between 1994 and 1999

Sl. No.	City/Town	Component	Purpose	Year		Total Cost (Rs. in '000)	Source of funding
				started	completed		
	1	2	3	4	5	6	7
	Class I						
	Gujarat						
1	Anand M	Purchase of vehicles	Improving transportation	1996	-	1,000	Self financed
		Purchase of vehicles	Improving transportation	1996	1996	240	Self financed
2	Bharuch M	Purchase of vehicles	Improving transportation	1996	1998	538	Self financed
		Purchase of equipment	Waste collection	1996	1998	878	Self financed
3	Bhuj M	Purchase of vehicles	Improving transportation	1998	-	400	State govt.
		Purchase of vehicles	Improving transportation	1998	1999	100	GMFB
4	Jamnagar M.Corp.	Purchase of vehicles	Improving transportation	1997	-	250	Self financed
		Purchase of vehicles	Improving transportation	1997	1999	2	Self financed
5	Junagadh M	Purchase of vehicles	Improving transportation	1994	1995	n.a.	n.a.
6	Nadiad M	Purchase of vehicles	Improving transportation	1996	-	19,754	Self financed
		Purchase of vehicles	Improving transportation	1997	1997	1,847	Self financed
7	Navsari M	Purchase of vehicles	Improving transportation	1995	ongoing	550	Self financed
8	Porbandar M	Purchase of vehicles	Improving transportation	1995	-	153	Self financed
		Purchase of vehicles	Improving transportation	1996	1996	831	Self financed
9	Rajkot M.Corp.	Purchase of vehicles	Improving transportation	1993	-	3,400	Self financed
10	Surendranagar M	Purchase of vehicles	Improving transportation	1994	-	1,750	GMFB
	Haryana						
11	Ambala MCl	Purchase of vehicles	Improving transportation	1994	-	149	State govt.
		Purchase of vehicles	Improving transportation	1995	1999	610	Self/ State govt.
12	Karnal MCl	Purchase of vehicles	Improving transportation	n.a.	n.a.	1,392	Self financed
	Jammu & Kashmir						
13	Srinagar M.Corp.	Earth filling / fencing	Landfill	1997	ongoing	15,000	State govt.
	Karnataka						
14	Tumkur M	n.a.	Waste disposal	1998	ongoing	5,000	
	Kerala						
15	Kozhikode M.Corp.	Compost plant	Treatment of waste	1998	2000	n.a.	State govt. (KUDFC)
16	Thalaserry M	Compost plant	Treatment of waste	1998	1998	150	Self financed
		Purchase of vehicles	Improving transportation	1996	1997	810	World Bank

Status of Municipal Solid Waste Management

C-12: Capital Works Undertaken between 1994 and 1999

Sl. No.	City/Town	Component	Purpose	Year started	Year completed	Total Cost (Rs. in '000)	Source of funding
	1	2	3	4	5	6	7
	Maharashtra						
17	Nashik M.Corp.	Compost plant	Treatment of waste	1999	2000	600	Self financed
	Punjab						
18	Moga MCl	Purchase of vehicles	Improving transportation	1996	-	800	Self financed
		Purchase of vehicles	Improving transportation	1997	1997	570	Self financed
	Rajasthan						
19	Ajmer MCl	n.a.	Improving transportation	1998	-	544	Self financed
		n.a.	Improving transportation	1998	-	211	Self financed
20	Beawar M	Purchase of equipment	Waste collection	1997	-	853	Self financed
		Purchase of vehicles	Improving transportation	1996	-	1,006	Self financed
21	Sriganganagar M	Purchase of vehicles	Improving transportation	1996	-	1,453	State govt.
	Tamil Nadu						
22	Rajapalaiyam M	Purchase of vehicles	Improving transportation	1995	1995	800	Self financed
23	Salem M.Corp.	Acquiring land	Waste disposal	1996	1997	15,709	State govt.
24	Tirunvannamalai M	Purchase of vehicles	Improving transportation	1997	-	1,382	Self financed
	West Bengal						
25	Santipur M	Purchase of vehicles	Improving transportation	n.a.	n.a.	235	n.a.
	Small States						
	Tripura						
26	Agartala MCl	Purchase of vehicles	Improving transportation	1997	-	9,700	Central govt.
		Compost plant	Treatment of waste	n.a.	n.a.	3,260	Central govt.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management
C-12: Capital Works Undertaken between 1994 and 1999

Sl. No.	City/Town	Component	Purpose	Year started	Year completed	Total Cost (Rs. in '000)	Source of funding
	1	2	3	4	5	6	7
	Class II						
	Gujarat						
1	Amreli M	Purchase of vehicles	Improving transportation	n.a.	n.a.	n.a.	Self financed
2	Dohad M	Purchase of vehicles	Improving transportation	1994	-	350	Self financed
		Purchase of vehicles	Improving transportation	1996	1996	400	Self financed
3	Gondal M	Purchase of vehicles	Improving transportation	1997	-	700	Self financed
		Purchase of vehicles	Improving transportation	1997	1997	210	Self financed
4	Jetpur M	Purchase of vehicles	Improving transportation	1994	-	500	Self financed
		Purchase of vehicles	Improving transportation	1997	1998	200	State govt.
	Haryana						
5	Kaithal MCl	n.a.	Waste collection	1998	1998	100	Self financed
	Karnataka						
6	Ramanagaram CMC	Purchase of vehicles	Improving transportation	1999	-	n.a.	Self financed
	Kerala						
7	Changanessary MC	Compost plant	n.a.	n.a.	n.a.	n.a.	n.a.
8	Taliparamba M	Acquiring land	Waste disposal	1998	1998	1,200	People's plan campaign fund
		Purchase of vehicles	Improving transportation	1997	1997	680	Self financed
	Madhya Pradesh						
9	Neemuch M	Purchase of vehicles	Improving transportation	1994	-	735	State govt.
10	Vidisha M	Purchase of equipment	Waste collection	1995	1996	n.a.	Central/ State govt.
		Trenching ground devt.	Waste treatment	1995	n.a.	n.a.	Central/ State govt.
	Tamil Nadu						
11	Arakkonam M	Purchase of vehicles	Improving transportation	1996	-	800	Self financed
12	Sivakasi M	Purchase of vehicles					
13	Srivilliputtur M	Purchase of vehicles	Improving transportation	1998	-	495	Self financed
14	Tindivanam M	Purchase of vehicles	Improving transportation	1995	-	n.a.	n.a.
	West Bengal						
15	Chakdaha M	Acquiring land	Develop land fill	1997	1998	780	10th Finance Commission Award

Status of Municipal Solid Waste Management

C-12: Capital Works Undertaken between 1994 and 1999

Sl. No.	City/Town	Component	Purpose	Year		Total Cost (Rs. in '000)	Source of funding
				started	completed		
	1	2	3	4	5	6	7
	Small States						
	Himachal Pradesh						
16	Shimla M.Corp.	Purchase of vehicles	Improving transportation	1999	-	6,082	NORAD
	Nagaland						
17	Kohima TC	Purchase of equipment	Waste disposal	1994	-	100	Self financed
	Union Territories						
18	Port Blair MCl						
	Others(Smaller than Class II towns)						
	Small States						
	Goa						
19	Panaji MCl	n.a.	n.a.	1994	n.a.	n.a.	HUDCO
	Sikkim						
20	Gangtok (Greater Gangtok) NTAC	Compost plant	Acquiring land	1997	1999	1,500	State govt.
		Compost plant	Treatment of waste	1999	1999	4,900	State govt.
	Union Territories						
21	Daman MCl	Purchase of vehicles	Improving transportation	1996	-	329	State govt.
22	Silvassa CT						

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-13: Capital Works to be undertaken in Future

Sl. No.	City/Town	Component	Purpose	Year		Total Cost (Rs. in '000)	Source of funding	Per capita cost (Rs.)
				started	completion			
	1	2	3	4	5	6	7	8
	Metropolitan Cities							
1	Bangalore M.Corp.	Purchase of vehicles	Improving transportation	2000	2001	250000	HUDCO	n.a.
2	Delhi M.Corp.	Purchase of vehicles/ equipment	Improving collection	2000	2005	600000	State govt.	n.a.
		Land fill	Disposal/ treatment of waste	2000	2010	580000	State govt.	n.a.
3	Surat M.Corp.	Compost plant	Treatment of waste	2000	2002	118550	n.a.	47
4	Vadodara M.Corp.	Purchase of vehicles	Improving transportation	1999	2001	1500	Self financed	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-13: Capital Works to be undertaken in Future

Sl. No.	City/Town	Component	Purpose	Year		Total Cost (Rs. in '000)	Source of funding	Per capita cost (Rs.)
				started	completion			
	Class I							
	Andhra Pradesh							
1	Guntur MCl	Pelletisation plant	Treatment of waste	1999	1999	n.a.	HUDCO	n.a.
2	Rajahmundry M.Corp.	Bio fertilizer plant	Treatment of waste	1999	2000	400000	State govt.	105
3	Tirupati MCl	Compost plant	Treatment of waste	1999	n.a.	10000	Self financed	n.a.
	Gujarat							
5	Anand M	Purchase of vehicles	Improving transportation	1998	1999	200	Self financed	n.a.
		Purchase of vehicles	Improving transportation	1998	1999	300	Self financed	n.a.
6	Bhuj M	Purchase of vehicles	Improving transportation	1998	1999	2000	GMFB	17
7	Jamnagar M.Corp.	Purchase of vehicles	Improving transportation	1999	1999	1463	Self financed	n.a.
		Purchase of vehicles	Waste collection	1999	1999	1220	Self financed	n.a.
8	Junagadh M	Purchase of vehicles	Improving transportation	1999	2000	800	District Development Board	n.a.
9	Porbandar M	Purchase of vehicles	Improving transportation	2000		1706	Self financed	
	Haryana							
10	Karnal MCl	Purchase of vehicles	Improving transportation	2000	2000	n.a.	Self financed	n.a.
	Jammu & Kashmir							
11	Srinagar M.Corp.	Compost plant	Treatment of waste	in pipeline			not decided	n.a.
		Plastic Recycling Unit		in pipeline			n.a.	
	Kerala							
12	Kollam MC	Compost plant	Treatment of waste	1999	2001	35000	Central/ State govt.	n.a.
13	Thalaserry M	Compost plant	Treatment of waste	2000	-	n.a.	HUDCO	n.a.
	Madhya Pradesh							
14	Guna M	Compost plant	Treatment of waste	n.a.	n.a.	n.a.	n.a.	n.a.
15	Murwara-Katni M.Corp.	Compost plant	Treatment of waste	n.a.	n.a.	n.a.	n.a.	n.a.
16	Satna M.Corp.	Purchase of vehicles	Improving transportation	2000	n.a.	n.a.	State govt.	n.a.
	Maharashtra							
17	Wardha M	Compost plant	Treatment of waste	n.a.	n.a.		HUDCO	n.a.

Status of Municipal Solid Waste Management

C-13: Capital Works to be undertaken in Future

Sl. No.	City/Town	Component	Purpose	Year		Total Cost (Rs. in '000)	Source of funding	Per capita cost (Rs.)
				started	completion			
	Punjab							
18	Jalandhar M. Corp.	Compost plant	Treatment of waste	1999	2000	n.a.	n.a.	n.a.
19	Moga MCl	Acquiring land	Develop land fill	2000	2001	1600	Self financed	11
		Purchase of vehicles/ equipment	Improving collection	1999	2000	1000	Self financed	n.a.
	Rajasthan							
20	Ajmer MCl	n.a.	Improving transportation	1999	2000	379	n.a.	n.a.
		n.a.	Improving transportation	1999	2000	151	n.a.	n.a.
21	Bhilwara M	n.a.	Waste disposal	2000	2001	50000	State govt. / HUDCO	222
22	Bikaner M	Compost plant	Treatment of waste	2001	n.a.	12000	Central govt.	20
23	Sriganganagar M	Purchase of vehicles	Improving transportation	2001	n.a.	240	State govt.	n.a.
	Tamil Nadu							
24	Tirunelveli M.Corp.	Compost plant	Treatment of waste	n.a.	n.a.	n.a.	TNUDF	n.a.
		Purchase of vehicles/equipment	Improving collection	1999	n.a.	41400	TNUDF/ loan/self	n.a.
25	Tirunvannamalai M	Compost plant equipment	Treatment of waste	2000	2000	54	Self financed	n.a.
	Uttar Pradesh							
26	Hardwar MB	n.a.	Waste disposal	n.a.	n.a.	77700	State govt.	n.a.
	Small States							
	Assam							
27	Guwahati M.Corp.	Dumping ground devt.	Waste disposal	n.a.	n.a.	n.a.	n.a.	n.a.
	Tripura							
28	Agartala MCl	Compost plant	Treatment of waste	2000	2002	235	State govt.	117

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.

Status of Municipal Solid Waste Management

C-13: Capital Works to be undertaken in Future

Sl. No.	City/Town	Component	Purpose	Year started	Year completion	Total Cost (Rs. in '000)	Source of funding	Per capita cost (Rs.)
	Class II							
	Gujarat							
1	Gondal M	Purchase of vehicles	Improving transportation	1999	2000	500	Self financed	n.a.
2	Jetpur M	Purchase of vehicles	Improving transportation	1997	1999	400	State govt.	n.a.
3	Palanpur M	Purchase of vehicles	Improving transportation	1999	2000	300	State govt.	n.a.
	Karnataka							
4	Gokak CMC	Compost yard	Treatment of waste	2000	2001	300	Self financed	n.a.
5	Rabkavi-Banhatti CMC	Purchase of vehicles	Improving transportation	n.a.	n.a.	n.a.	Central govt.	n.a.
6	Ramanagaram CMC	Treatment facility	Treatment of waste	1999		9980	International loan	n.a.
	Kerala							
7	Changanessary MC	Compost plant	Treatment of waste	n.a.	n.a.	n.a.	State govt.	n.a.
8	Payyanur M	Acquiring land	Treatment of waste	2004	2005	16000	State govt.	n.a.
9	Taliparamba M	Compost plant	Treatment of waste	2000	2000	1000	People plan campaign fund	n.a.
	Madhya Pradesh							
10	Shahdol M	Acquiring land	Treatment facility	n.a.	n.a.	n.a.	n.a.	n.a.
	Tamil Nadu							
11	Sivakasi M	Purchase of vehicles	Waste disposal	1999	2000	1200	Self financed	n.a.
12	Srivilliputtur M	Acquiring land	Treatment of waste	2000	2001	25	Self financed	n.a.
	West Bengal							
13	Jalpaiguri M	Compost plant	Treatment of waste	2000	2000	1500	International assistance	15
	Small States							
	Himachal Pradesh							
14	Shimla M.Corp.	Waste recycling plant	Waste treatment	n.a.	n.a.	n.a.	n.a.	n.a.
	Nagaland							
15	Kohima TC	Purchase of equipment	Waste disposal	2000	2001	20000	Central govt./ HUDCO	210
	Others(Smaller than Class II towns)							
	Small States							
	Sikkim							
16	Gangtok (Greater Gangtok)	Compost plant	Waste treatment	2001	2005	25000000	n.a.	230
	Union Territories							
17	Silvassa CT	Purchase of vehicles	Improving transportation	1998	1999	1000000	State govt.	n.a.

Source: Respective urban local governments/relevant agencies, NIUA Survey, 1999.